EXHIBIT 13

Patent Holdup and Royalty Stacking*

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We study several interconnected problems that arise under the current U.S. patent system when a patent covers one component or feature of a complex product. This situation is common in the information technology sector of the economy. Our analysis applies to cases involving reasonable royalties but not lost profits. First, we show using bargaining theory that the threat to obtain a permanent injunction greatly enhances the patent holder's negotiating power, leading to royalty rates that exceed a natural benchmark range based on the value of the patented technology and the strength of the patent. Such royalty overcharges are especially great for weak patents covering a minor feature of a product with a sizeable price/cost margin, including products sold by firms that themselves have made substantial research and development investments. These royalty overcharges do not disappear even if the allegedly infringing firm is fully aware of the patent when it initially designs its product. However, the holdup problems caused by the threat of injunctions are reduced if courts regularly grant stays to permanent injunctions to give defendants time to redesign their products to avoid infringement when this is possible. Second, we show how holdup problems are magnified in the presence of royalty stacking, i.e., when multiple patents read on a single product. Third, using third-generation cellular telephones and Wi-Fi as leading examples, we illustrate that royalty stacking can become a very serious problem, especially in the standard-setting context where hundreds or even thousands of patents can read on a single product standard. Fourth, we discuss the use of "reasonable royalties" to award damages in patent infringement cases. We report empirical results regarding the measurement of reasonable royalties by the courts and identify various practical problems that tend to lead courts to overestimate reasonable royalties in the presence of royalty stacking. Finally, we make suggestions for patent reform based on our theoretical and empirical findings.

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* © 2007 Mark A. Lemley & Carl Shapiro. We are grateful to Apple Computer, Cisco Systems, Intel, Micron Technology, Microsoft, and SAP for funding the research reported in this Article. We emphasize that our conclusions are our own, not theirs. We thank Ashish Arora, Chris Cotropia, Peter Detkin, Sandra Draibye, Charles Eskridge, Joseph Farrell, John Flynn, John Golden, Rose Hagan, Tim Holbrook, John Hayes, Paul Krieger, Amy Landers, Matt Lynde, David McGowan, Alan Morrison, Craig Nard, Arti Rai, Michael Samardzija, David Simon, Mallun Yen, and participants at workshops at Stanford Law School, the University of Texas School of Law, and the University of California at Berkeley for comments on a previous draft. We are also grateful to Jackie Chou for research assistance and data collection.

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I. Introduction

The patent system is designed with a paradigm invention in mind—a new device or machine covered by a single patent. Historically, this paradigm was a fairly accurate portrayal of the typical patent.[1] As Robert Merges put it, "for Jefferson, if you put technology in a bag and shook it, it would make some noise."[2] In the last few decades that has begun to change markedly. Not only have patents on chemical, biotechnological, hardware, and software inventions proliferated, but more and more products incorporate not a single new invention but a combination of many different *components*, each of which may be the subject of one or more patents.[3] In the information technology sector in particular, modern products such as microprocessors, cell phones, or memory devices can easily be covered by dozens or even hundreds of different patents. As a striking example, literally thousands of patents have been identified as essential to the proposed new standards for 3G cellular telephone systems.[4]

The fact that a great many patents can read on a single product, and that this is common in certain critical industries, creates numerous practical problems for the operation of the patent system.[5] We focus here on two critical, interacting areas in which problems arise: *injunction threats* and *royalty stacking*. We are especially interested in how these problems affect the royalties that will be negotiated between patent holders and downstream firms that produce products that may infringe those patents. After all, since far more patents are licensed or settled than litigated to judgment, the primary eeonomic effect of rules governing patent litigation arises through the effect of those rules on the licensing terms that are negotiated in the shadow of litigation.

The threat that a patent holder will obtain an injunction that will force the downstream producer to pull its product from the market can be very

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1. John R. Allison & Mark A. Lemley, *The Growing Complexity of the United States Patent System*, 82 B.U. L. REV. 77, 93 tbl.1 (2002) (noting that until quite recently the majority of all U.S. patents were for mechanical inventions).

2. Robert P. Merges, *As Many As Six Impossible Patents Before Breakfast: Property Rights for Business Concepts and Patent System Reform*, 14 BERKELEY TECH. L.J. 577, 585 (1999).

3. We have occasionally seen problems like this before. *See* Ted Sabety, *Nanotechnology Innovation and the Patent Thicket: Which IP Policies Promote Growth?*, 15 ALB. L.J. SCI. & TECH. 477, 495–503 (2005) (discussing the example of radio patents in the 1920s). But they are much more common now than they were in the past.

4. David J. Goodman & Robert A. Mycrs, *3G Cellular Standards and Patents*, *in* PROCEEDINGS OF IEEE INTERNATIONAL CONFERENCE ON WIRELESS NETWORKS, COMMUNICATIONS AND MOBILE COMPUTING 2 (2005), *available at* http://eeweb.poly.edu/dgoodman/wirelesscom2005.pdf.

5. For further discussion of how numerous patents often read on a single product, see Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anti-Commons in Biomedical Research*, 280 SCIENCE 698 (1998) (describing how biomedical researchers underuse scarce resources because the proliferation of IP rights allows owners to restrict use) and Carl Shapiro, *Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting*, *in* 1 INNOVATION POLICY AND THE ECONOMY 119, 119–23 (Adam B. Jaffe et al. eds., 2001) (discussing the "patent thicket's" effect on cumulative technological development).

powerful. These threats can greatly affect licensing negotiations, especially in cases where the injunction is based on a patent covering one small component of a complex, profitable, and popular product. Injunction threats often involve a strong element of *holdup* in the common circumstance in which the defendant has already invested heavily to design, manufacture, market, and sell the product with the allegedly infringing feature. As we show below, the threat of an injunction can enable a patent holder to negotiate royalties far in excess of the patent holder's true economic contribution. Such royalty overcharges act as a tax on new products incorporating the patented technology, thereby impeding rather than promoting innovation.

Royalty stacking refers to situations in which a single product potentially infringes on many patents, and thus may bear multiple royalty burdens. The term "royalty stacking" reflects the fact that, from the perspective of the firm making the product in question, all of the different claims for royalties must be added or "stacked" together to determine the total royalty burden borne by the product if the firm is to sell that product free of patent litigation. As a matter of simple arithmetic, royalty stacking magnifies the problems associated with injunction threats and holdup, and greatly so if many patents read on the same product. In this key sense, the problems of injunction threats and royalty stacking are intertwined.

In Part II, we explain how the threat of an injunction can dramatically influence the negotiations between a single patent owner and an alleged infringer, especially if the patented technology covers one component of a complex product.[6] We identify the key economic variables that determine the royalty rate that economic theory predicts will be negotiated between the patent holder and the alleged infringer. We show how the threat that the patent holder will obtain an injunction causes the negotiated royalty rate to exceed the true economic contribution of the patent holder, especially if the value of the patented technology is small relative to the value created by the product as a whole. We also explain why the threat of an injunction is especially troublesome in the case of weak patents, i.e., patents that may well be found invalid if actually litigated.

Part III addresses the additional problems that arise when holdup occurs along with royalty stacking. In part, these added problems result from simple arithmetic: the combined royalty rate owed to all of the patent holders asserting infringement is equal to the sum of the royalties owed to each individual patent holder. But the problem also resides in legal rules for royalty calculation that do not sufficiently account for the presence of other inventions included in the infringing product. Unfortunately, the rules

6. We expressly do not consider in our analysis portfolio patent licensing, which presents different issues than the ones we address here. For a discussion of such issues, see Richard J. Gilbert & Michael L. Katz, *Should Good Patents Come in Small Packages? A Welfare Analysis of Intellectual Property Bundling*, 24 INT'L J. INDUS. ORG. 931, 934–46 (2006) and Gideon Parchomovsky & R. Polk Wagner, *Patent Portfolios*, 154 U. PA. L. REV. 1, 64 (2005).

commonly used by the courts to assess reasonable royalties can perform especially poorly in the combined presence of injunction threats and royalty stacking.

Part IV analyzes a third problem that operates in combination with injunction-based holdup and royalty stacking—the systematic overcompensation of patent owners in component industries through reasonable-royalty damage awards. For a variety of reasons, the legal standard used to set reasonable royalties may not work well in practice when the patent is only a small component of a much larger product but the royalty must be calculated based on the larger product.

Part V complements our theoretical work by providing two types of empirical evidence of royalty stacking. Subpart V(A) discusses selected case studies of royalty stacking to illustrate the nature and magnitude of the problems that can arise for companies seeking to commercialize new products. Subpart V(B) provides systematic evidence based on a study of reported decisions awarding reasonable royalties as damages for patent infringement. This evidence suggests that there are indeed very real problems associated with royalty stacking. The courts applying the rules for computing reasonable royalties have to some degree helped mitigate those problems by granting lower royalty rates to component inventions and to inventions in the electronics and information technology industries. Nonetheless, economic theory, the empirical evidence, and our own experience as practitioners all indicate that these judicial efforts have not fully solved the problems associated with injunction threats and royalty stacking.

In Part VI, we make a series of proposals for judicial and legislative reform to address the dual problems of injunction threats and royalty stacking as they apply in the information technology sector of the economy. Our proposals for patent reform fall into two areas: the rules for granting permanent injunctions and the methods used to calculate reasonable royalties. We also urge that the antitrust treatment of cross licenses, patent pools, and collective standard setting take careful account of how these market arrangements promote competition by working around flaws in the patent system. The goal of the reforms we advocate is not to favor accused infringers over patent owners; the patent system provides needed incentives and must continue to do so. Rather, our goal is to make sure that the reward patent owners can reap bears some reasonable relationship to the value of the ideas they contribute, so that patent holdup does not distort or even dampen innovation incentives.

II. Injunction Threats and Negotiated Royalty Rates

We are concerned in this Article with situations in which a downstream firm produces a complex product that potentially or allegedly infringes many patents. Each patent holder's threat to obtain an injunction is fundamental to licensing negotiations in these settings. In this Part, we explain how

injunction threats affect patent licensing negotiations when a *single* patent holder alleges infringement against the downstream firm.[7] This analysis will serve as a building block for our analysis of royalty stacking in Part III.

A. Basic Economic Model

Consider a downstream firm that is approached by a patent holder who alleges that the downstream firm's product incorporates a feature that infringes its patent. Suppose, for now, that the downstream firm is already selling its product when it learns of the patent claim. This timing may result because the downstream firm designed its product to include a feature for which a patent application was subsequently published or a patent was subsequently issued, perhaps after the patent holder amended its initial claims to capture the downstream firm's product.[8] Alternatively, the downstream firm may simply have been unaware at the time it designed its product that the patent now being asserted had been issued, or it may have been aware of the patent but had no reason to believe the patent owner would argue that the downstream firm's product infringed it. Further, in some cases, the patent holder can engage in strategic delay or concealment, knowing it will be in a stronger bargaining position once the downstream firm has already designed its product incorporating the patented feature.[9] Regardless of these particulars, we ask how the patent holder's threat to obtain an injunction influences the royalty rate that the two parties are likely to negotiate in this situation.

We now sketch out a model of the process by which patent licenses are negotiated and patents are litigated. One must employ some type of model to analyze the impact of injunction threats on negotiated royalty rates. We believe our model is the simplest possible game-theoretic model rich enough for this purpose.

The patent holder and the downstream firm negotiate over a royalty rate. Using the standard economic theory of Nash bargaining, the negotiated royalty rate depends upon the payoff that each party would obtain if the

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7. The analysis in this Part draws heavily on Carl Shapiro's work. Carl Shapiro, *Injunctions, Hold-Up, and Patent Royalties* 1 (Competition Policy Ctr., Working Paper No. CPC06-062, 2006), *available at* http://faculty.haas.berkeley.edu/shapiro/royalties.pdf (deriving the equations and relationships asserted here).

8. In that case, one of us has argued for granting the downstream firm prior-user rights, in which case it would not have to pay any royalties at all. *See* Carl Shapiro, *Prior User Rights*, 96 AM. ECON. REV. (PAPERS & PROC.) 92, 95 (2006) (stating that when nearly simultaneous, independent invention occurs, awarding prior-user rights can enhance competition and produce a better alignment of private and social incentives); *see also* Carl Shapiro, *Patent Reform: Aligning Reward and Contribution*, *in* 7 INNOVATION POLICY AND THE ECONOMY (Adam B. Jaffe et al. eds., forthcoming 2007) (explaining the economic benefits of an expanded independent invention defense in patent infringement cases); Samson Vermont, *Independent Invention as a Defense to Patent Infringement*, 105 MICH. L. REV. 475, 494–500 (2006) (proposing a broader reinvention defense).

9. The law has some mechanisms to limit such intentional delay, such as the twenty-year patent term and the doctrine of prosecution laches, but they are not particularly robust.

negotiations break down, i.e., on each party's *threat point* in the licensing negotiations. If no licensing agreement is reached, the patent holder sues the downstream firm for patent infringement, forcing both firms to bear certain litigation costs. Litigation takes some time, and the outcome of the patent litigation is uncertain. The patent will be found valid and infringed with some probability, which we call the "patent strength." If the patent is ruled invalid or not infringed, the downstream firm, of course, owes nothing to the patent holder and is free to keep selling its product without any royalty obligations. However, if the patent is ruled valid and infringed, the downstream firm must pay reasonable royalties to the patent holder for any past infringement, and we assume (for now) that the court enters an injunction preventing the downstream firm from selling the infringing product.[10] In that event, the two firms again sit down to negotiate a license. Having won the patent litigation and obtained an injunction, the patent holder clearly is in a very strong position. If *these* negotiations break down, the downstream firm cannot sell the infringing product and must withdraw it from the market unless and until the firm can introduce a redesigned version that does not contain the patented feature, or until the patent expires.

The following economic variables govern the royalty rate that will be negotiated in this setting:

- V: The *Value* per unit of the patented feature to the downstream firm in comparison with the next best alternative technology. For example, if the patented feature enhances the value of the product to consumers by $1 over the next best alternative, then $V = \$1$. Similarly, if it reduces the cost of manufacturing the good by $1, then $V = \$1$.
- M: The *Margin* per unit earned by the downstream firm on its product. For example, if the product is sold at a price of $40 and the marginal cost is $30, then $M = \$40 - \$30 = \$10$. Such margins often enable downstream firms to earn a return on their own innovative efforts.
- θ: The *Strength* of the patent, i.e., the probability that litigation will result in a finding that the patent is valid and infringed by the downstream firm's product. Critically, we assume there is no way to determine with certainty whether the patent is valid and infringed without litigating to judgment. Therefore, it is not possible

10. Until 2006, the Federal Circuit treated injunctions as effectively mandatory after a finding of patent infringement. *See* MercExchange, L.L.C. v. eBay, Inc., 401 F.3d 1323, 1339 (Fed. Cir. 2005), (following "the general rule that courts will issue permanent injunctions against patent infringement absent exceptional circumstances"), *vacated*, 126 S. Ct. 1837 (2006). The Supreme Court's decision in *eBay* replaced that rule with a case-specific, four-factor test for deciding whether injunctive relief is appropriate. eBay Inc. v. MercExchange, L.L.C., 126 S. Ct. 1837, 1838–39 (2006). At this writing, the Federal Circuit had not applied that test in a challenge to a permanent injunction. We discuss the proper application of the new *eBay* test in Part VI.

for the downstream firm to fully resolve the uncertainty about validity and infringement before making its investment decisions.[11]

- *C*: The *Cost* to the downstream firm of redesigning its product to avoid infringing the patent claims, measured as a fraction of the total value of the patented feature. For example, if the per-unit value of the patented feature is $V = \$1$ and the downstream firm expects to sell 10 million units, then the total value of the patented feature is $10 million. If redesigning the product costs $2 million, then *C* is equal to $2 million/$10 million or 20%. In general, there is nothing to prevent *C* from exceeding 100%. Indeed, *C* will exceed 100% if the redesign costs are significant and the feature covered by the patent could be implemented almost as well using a noninfringing alternative, so that *V* is small. It is also possible that *C* could be so large that redesigning the product is not commercially feasible.
- *L*: The fraction of the downstream firm's total unit sales during the lifetime of the patent that would be *Lost* if the downstream firm were forced off the market by an injunction. These lost sales reflect, in part, the lag in time required for the downstream firm to redesign a noninfringing product and introduce it to the market. These lost sales also depend upon the ability of the downstream firm to successfully resume making sales once it has redesigned its product. For example, with strong network effects, the downstream firm, having fallen behind its rivals in building an installed base of users, may not be able to profitably return to the market after the disruption caused by the injunction.
- *B*: The *Bargaining* skill of the patent holder, as measured by the fraction of the combined gains from settling, rather than litigating, that are captured by the patent holder. This variable falls between 0 and 1. Equal bargaining skill, $B = 0.5$, is a common assumption.

The concept of bargaining skill, *B*, must be distinguished from the threat points. To illustrate, suppose that a buyer values a certain new product at $100, and the seller's marginal cost of producing that product is $40. If the buyer has no viable alternative to this product, the buyer's threat point is to not buy the product, and the seller's threat point is to not sell the product. Reaching a deal generates gains from trade of $100 − $40 = $60 in comparison with those threat points. With equal bargaining skill, these gains would be split equally, leading to a price of $70. Buyer and seller would each

11. A more complex model of the litigation process would recognize that the patent holder and downstream firm update their views on patent strength as information is elicited during the litigation process, and that they can negotiate a license throughout this process. Information learned during the litigation process can be modeled as inducing a mean-preserving spread on patent strength. Joseph Farrell & Carl Shapiro, How Strong Are Weak Patents? 16–17 (Jan. 2007) (unpublished manuscript), *available at* http://faculty.haas.berkeley.edu/shapiro/weak.pdf.

capture a $30 surplus. Now, modify this example by assuming that the buyer has the alternative of buying an older, less attractive product that lacks certain features present in the new product. Suppose that the older product is available at a price of $40 (perhaps the older product is supplied competitively at its marginal cost of $40), but the buyer only values the older product at $80. Now the buyer's threat point is to buy the older product, which would generate buyer surplus of $80 − $40 = $40. The seller's threat point is unchanged. Now the gains from trade between the buyer and seller are only $20 (the $60 total surplus available from the new product less the $40 available from the older product); these gains from trade reflect the enhanced value of the new product over the old product. With equal bargaining skill, these gains are split, leading to a price of $50. The seller gets $10 surplus ($50 price less $40 marginal cost) from trading with the buyer. The buyer gets a $50 surplus ($100 value less $50 price), $10 of which results from trading with the seller, and $40 of which the buyer could have obtained by purchasing the older product. Introducing the older product changes the buyer's threat point (from $0 to $40 of buyer surplus), which allows the buyer to negotiate a lower price ($50 rather than $70), for a given level of bargaining skill ($B = 0.5$).

In this example, changing the buyer's threat point changed the bargaining outcome, holding bargaining skill constant. Likewise, changing the bargaining skill for a given set of threat points also changes the bargaining outcome. To illustrate, return to the case in which the older product was unavailable, but now suppose that the seller is (for some reason) just a better bargainer, so the seller captures 60% of the gains from trade. Without the older product, the gains from trade were $60, so the seller now captures 60% of these, or $36, as surplus, which implies a price of $76; the buyer's surplus would be 40% of $60, or $24, which fits with the price of $100. In this Article, we focus on how injunctions affect the threat points in bargaining over patent royalties. We make the neutral assumption that the bargaining skill, B, does not change when the threat points change. Equal bargaining skill, $B = 0.5$, is a natural special case.[12] But as we show, the model will produce similar results with any value of B.

12. In his classic article *The Bargaining Problem*, John Nash provided a simple formula characterizing the bargaining outcome in a wide class of bargaining situations, so long as certain bargaining axioms (including efficiency) are assumed to hold. John F. Nash, Jr., *The Bargaining Problem*, 18 ECONOMETRICA 155 (1950). In our setting, the Nash bargaining solution implies that the parties split the gains from trade equally, i.e., $B = 0.5$. More recently, Ariel Rubinstein showed how the bargaining skill parameter is determined in the noncooperative equilibrium in a game in which the two parties alternate in making offers that can then be accepted or rejected. Ariel Rubinstein, *Perfect Equilibrium in a Bargaining Model*, 50 ECONOMETRICA 97, 104–06 (1982). If the time between offers is short and the players discount the future equally, B again equals 0.5. *Id.* at 107–08.

B. Benchmark Royalty Level

Our goal is to understand how the patent holder's threat to obtain an injunetion affects the negotiated royalty rate. Before providing that discussion, we first develop a benchmark level for the royalty rate, i.e., the royalty rate that would be reasonable and expected in the ideal patent system *without* any element of holdup.

We illustrate our benchmark using a numerical example. Suppose that two firms have equal bargaining skill, so they split equally any gains from reaching an agreement. This corresponds to a value of $B = 0.5$. Suppose that a patented feature is worth $V = \$1$ per unit to the downstream firm, compared with the best noninfringing alternative.

If the patent were surely valid, and if holdup were not a factor in the negotiations, the two firms would split the gains of $1.00 per unit from using the patented technology, which would lead to a royalty rate of $0.50 per unit. More generally, the benchmark royalty rate for an ironclad patent is equal to $B \times V$.[13] We also consider this the proper benchmark for reasonable royalties, since reasonable royalties are meant to reflect the royalty rate that would be negotiated, prior to any infringement, if the patent were known to be valid.[14]

Because the royalty negotiations take place before a final court decision, the benchmark royalty rate must be discounted to reflect patent strength. To illustrate, suppose that there is a 40% chance that the patent will be found valid and infringed. Absent any holdup, the benchmark royalty rate would just be 40% of the value that would apply if the patent were ironclad. In our numerical example above, the benchmark for an ironclad patent was $0.50 per unit, so the benchmark for the same patent with strength 40% equals $0.20 per unit.[15] More generally, the benchmark royalty rate is given by $\theta \times B \times V$, where θ is the patent strength.[16] This benchmark has the very attractive property that the patent holder's reward is proportional to patent

13. We are agnostic about the patent holder's bargaining skill as measured by the variable B. Our analysis and conclusions apply regardless of the value of B. Indeed, the percentage royalty "overcharges" we compute below are independent of B. However, readers may find it useful to simplify our results by assuming that $B = 0.5$.

14. *See, e.g.*, ROGER D. BLAIR & THOMAS F. COTTER, INTELLECTUAL PROPERTY: ECONOMIC AND LEGAL DIMENSIONS OF RIGHTS AND REMEDIES 229–30 (2005).

15. The patent holder's contribution is $0 with probability 0.6 and $1 with probability 0.4, for an expected value of $0.40. With equal bargaining skill, the patent holder captures half of this value, or $0.20 per unit.

16. In general, the benchmark royalty also will reflect the parties' litigation costs, and the model in Shapiro, *supra* note 7, does in fact include those costs. However, if the parties have equal litigation costs and equal bargaining skill, including litigation costs does not alter the benchmark royalty rate. More generally, because litigation costs are relevant in both the benchmark and the holdup royalty calculations, they drop out of the comparison of the two and are of no significance for our purposes.

strength, i.e., to the probability that the patent holder in fact owns a valid right covering an innovation that the downstream firm is using.[17]

Our discussion below is framed in terms of the gap between the negotiated royalty rate and this benchmark level. We explain how this gap, effectively a royalty "overcharge," is driven by the threat of obtaining an injunction and the rules by which reasonable royalties are calculated.

We should be clear that we do not mean that the benchmark royalty is the "right price" that should displace the workings of the market. To the contrary, as our use of the Nash bargaining model suggests, we are agnostic on how the cooperative surplus from bargaining is actually divided between the parties. We are, however, concerned to ensure that the law does not change the threat points that set the boundary conditions for this bargaining in ways that systematically move it away from the benchmark. If the law does so, the result, especially for weak patents, is that the patent system has distorted the market allocation of resources.

C. Negotiated Royalty Rates

The negotiated royalty rate depends upon the downstream firm's best strategy in the event that negotiations with the patent holder break down. Two cases are relevant and realistic in the settings of interest to us here, where the patent covers one feature of a complex product whose production involves significant fixed costs, including research and development (R&D) costs, which must be recovered in the form of margins between price and marginal cost.

The first case arises when the downstream firm's best strategy, if negotiations break down, is to defend the patent suit and redesign its product only if it loses that suit and is unable to negotiate a license after losing. We call this the "Litigate" strategy. The second case arises when the downstream firm's best strategy is to develop a noninfringing version of its product while the patent litigation is pending so that it has an immediate backup plan in place in case it loses the patent litigation and faces an injunction. We call this the "Redesign and Litigate" strategy. We consider these two cases in turn.[18]

In both of these cases, the formula for the negotiated royalty depends upon the level of reasonable royalties that the court would apply. For now, we make the optimistic assumption that reasonable royalties are at the benchmark level of $B \times V$. If a higher figure is used for reasonable royalties, the negotiated royalties are even higher than discussed here. Below, we

17. Farrell and Shapiro, *supra* note 11, provide a formal welfare foundation for the benchmark $\theta \times B \times V$ in a model where $B = 1$.

18. There are of course other possible strategies, and they are discussed in more detail in Shapiro, *supra* note 7, at 12–14.

discuss at some length the problems that arise in practice when the courts seek to implement the concept of reasonable royalties.

1. Litigate Strategy.—An accused infringer will litigate without redesigning if the patent is relatively weak, and if the redesign costs are relatively high in comparison with profits that the downstream firm would lose by withdrawing from the market while redesigning its product. Accused infringers employing this strategy are taking their chances that they can beat the patent in court, a strategy that makes sense at least for some patents, especially weak ones. In this case, the owner of that weak patent gains great bargaining leverage from its ability to threaten to force the downstream firm from the market if the patent is found valid and infringed, especially if the lion's share of the value associated with the downstream firm's product has nothing to do with the patented feature.

In this case, the percentage gap between the negotiated royalty and the benchmark level is given by $C + \frac{M-V}{V} \times L$. The first term reflects the fact that the downstream firm will be forced to incur duplicative expenses to redesign its product if it loses the patent litigation. If the costs of redesigning the product are equal to C = 20% of the value of the patented feature, then this term equals precisely that 20%.[19] The second term reflects the fact that the downstream firm will be forced from the market by an injunction while redesigning its product if it loses the patent litigation. For a complex product and a minor patented feature, the second term can be very large. For example, if M = \$10, V = \$1, and if the injunction would cause the downstream firm to lose 10% of the total unit sales expected during the patent lifetime because it is forced off the market until the redesign can be implemented, then this term is $\frac{10-1}{10} \times 0.1 = 0.9$, corresponding to a 90% gap between the negotiated royalty and the benchmark level.[20] The reason this number is so large is that the downstream firm loses all sales of the downstream product by engaging in redesign, which causes it to lose margins that are far in excess of the value of the patented invention. Combined with the first term, the total overcharge equals 110%, so the negotiated royalty rate is more than double the benchmark level in this numerical example.

More generally, this analysis implies that the negotiated royalty rate for a single patent tends to be greatly elevated above a reasonable benchmark level if the value of the patented feature is small relative to the total value

19. The negotiated royalty rate is, of course, a function of the probability θ that the patent would be found valid. However, the patent strength, θ, does not appear in the expression for the percentage royalty overcharge because we are measuring the negotiated royalty rate as a percentage of the benchmark rate, and θ appears in both the numerator and the denominator of this ratio.

20. The Litigate strategy is indeed optimal for the downstream firm with these numbers so long as $\theta \times B \leq 2/9$. With equal bargaining skill, B = 1/2, the Litigate strategy is optimal if the patent strength is less than 4/9.

associated with the product. The intuition is that the accused infringer will lose the full value of its product, not just the value of the patented component, if it is enjoined and has to redesign the product to avoid infringement. It will therefore be willing to settle for an amount that is greater than the expected value of the patentee's contribution but less than the expected loss in sales of the unpatented components of its product.

2. Redesign and Litigate Strategy.—If the patent appears stronger, the accused infringer can avoid the risk of disruption in its business by redesigning the product even while litigating, particularly if the cost of redesign is relatively low in comparison with profits that the downstream firm would lose by withdrawing from the market while redesigning its product.[21] In this case, the patent holder benefits greatly from the fact that the downstream firm's threat point in the negotiations involves incurring redesign costs for sure, not just in the event that the patent holds up in litigation. Therefore, the patent holder's negotiating position is not properly discounted to reflect patent strength.

In this case, the percentage gap between the negotiated royalty and the benchmark level is given by $\frac{C}{\theta}$. For an ironclad patent, $\theta = 1$, and this term just equals C, the same as the first term in the case where the Litigate strategy is optimal for the downstream firm. Recall that C measures the redesign costs as a fraction of the total value of the patented feature. For weaker patents, however, this figure is magnified; if the patent strength is 50%, the royalty overcharge associated with redesign costs is doubled. For example, if $\theta = 50\%$ and if the costs of redesigning the product are $C = 20\%$ of the value of the patented feature, the overcharge equals 40%. The intuition here is straightforward—the accused infringer will have to spend money on a redesign that will be wasted if the patent is invalid or not infringed. It will therefore be willing to settle for an amount that is greater than the expected value of the patentee's contribution but less than the cost of redesigning the product while litigating.

D. What If the Patented Feature Is Nothing Special?

We now comment on the special case in which the patented feature is nothing special, in the sense that there are alternative ways to achieve the same product performance without infringing the patent. Formally, this is the case in which $V = 0$. This corresponds to the case in which the downstream firm has unwittingly designed a patented feature into its product, even though it could have used an equally good unpatented alternative had it known in advance about the patent.

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21. *See* MercExchange, L.L.C. v. eBay, Inc., 401 F.3d 1323, 1325–26 (Fed. Cir. 2005) (noting that eBay replaced the disputed method of selling with another method), *vacated*, 126 S. Ct. 1837 (2006).

In this case, we cannot talk about the percentage gap between the negotiated royalties and the benchmark level since the benchmark royalty level is 0, reflecting the fact that the patented feature adds no value above and beyond the next best alternative. Therefore, all of the negotiated royalty rate represents an overcharge based on holdup.

If the downstream firm's optimal strategy is Litigate, then the negotiated royalty rate in this case is equal to $\theta \times B(M \times L + K)$, where K is the redesign cost per unit.[22] For example, with equal bargaining skill ($B = 0.5$) and a patent strength of $\theta = 0.4$, and using the same numbers as above, namely $M = \$10.00$, $L = 0.1$, and a redesign cost of \$0.20 per unit, the negotiated royalty rate equals \$0.24 per unit. These royalties are earned by the holder of a patent that made no real economic contribution at all to the downstream firm's product; they are entirely a function of the risk that the patent will be held valid and infringed and the accused infringer will lose sales of the valuable parts of the product while redesigning it to avoid infringement. Put differently, the negotiated royalties can be attributed entirely to holdup and opportunism by the patentee.

Alternatively, if the downstream firm's optimal strategy is Redesign and Litigate, then the negotiated royalty rate equals $B \times K$. With these same numbers, except a stronger patent, $\theta = 0.5$, the negotiated royalty rate equals \$0.25 per unit.[23] Again, these royalties are earned by the holder of a patent that made no real economic contribution to the downstream firm's product but is in a position to capture part of the avoided cost of redesign.

These results occur in the simple one-patent model. Below we will discuss what happens when a single product can potentially infringe many such patents, each covering a patented feature that was arbitrary, in the sense that it could easily have been replaced with an alternative feature had the downstream firm known about the patent before it designed its product.[24]

E. Early Negotiations Do Not Help (Much)

So far we have assumed that the downstream firm designed its product before it was approached by the patent owner and faced with an infringement allegation. Naturally, this timing is conducive to the patent owner holding up the downstream firm since by the time the downstream firm learns that it is accused of infringing, it has already incurred design costs that would need to be wastefully duplicated if the downstream firm were forced to redesign its product to avoid infringing. Therefore, one might imagine that the problems just identified largely go away if the patent holder and the downstream firm

22. We can no longer talk about the design cost C as a fraction of the underlying value of the patented feature since the latter is 0. When $V > 0$, C and K are related by $C = K/V$.

23. The stronger patent makes Redesign and Litigate rather than Litigate optimal for the downstream firm.

24. *See infra* Part III.

engage in "early negotiations," i.e., negotiations before the product is designed.

There are indeed two polar cases in which early negotiations ensure that the negotiated royalty equals the benchmark level. The first polar case occurs when the patented feature is nothing special, i.e., $V = 0$. In that case, if the downstream firm is aware of the patent before it designs its product, it can costlessly avoid infringing, so the negotiated royalty rate equals the benchmark level of 0. This case requires either that the downstream firm not infringe on *another* patent by designing around the first one, or that the downstream firm can identify and negotiate with the other patent holders prior to designing its product. The second polar case involves an ironclad patent, in which case the royalty rate arising from early negotiations equals $B \times V$, the benchmark level.

Apart from these polar cases, however, and especially for weak patents, the royalty overcharges studied above persist even if the patent holder approaches the downstream firm before that firm has designed its product. We now explain this somewhat surprising result.

What is different about the negotiations between the patent holder and the downstream firm if the latter has not yet designed its product? There is no change in the negotiated outcome predicted by standard bargaining theory unless the early knowledge creates a new, superior threat point for the downstream firm that was not available in the previous analysis, where we assumed that the downstream firm had already incurred the design costs at the time of negotiation. More specifically, the ability to negotiate early enables the downstream firm to negotiate better terms if and *only if* the downstream firm's optimal strategy without a license, and thus its threat point in the early negotiations, is to design its product to avoid infringing the patent.

Once one recognizes that patents are probabilistic,[25] this proves to be a discouraging observation. If the downstream firm's threat in the early negotiations is to design its product to avoid using the patented feature, then the negotiated royalty rate will equal the patent holder's share of the value associated with that feature. In our example where the feature adds $1.00 per unit in value, with equal bargaining skill the negotiated royalty rate would be $0.50 per unit. More generally, if the opportunity to negotiate early is valuable at all to the downstream firm, then the negotiated royalty rate will equal $B \times V$. The key thing to note about this royalty rate is that it *does not involve any discounting based on patent strength*. There is no such discounting because if licensing negotiations break down, the downstream firm will design its product to avoid infringing, which involves foregoing the use of

25. *See* Mark A. Lemley & Carl Shapiro, *Probabilistic Patents*, 19 J. ECON. PERSP., Spring 2005, at 75, 95 (concluding that patents are not the well-defined property rights that some economic models assume, and demonstrating that patents contain a greater level of uncertainty than other property rights).

the patented feature for sure, not merely in the event that the patent would be proven invalid. The downstream firm cannot adopt a strategy of "redesign only if the patent is valid" without exposing itself to holdup if the patent is valid.

If the opportunity to negotiate early is valuable at all to the downstream firm, the percentage gap between the negotiated royalty rate and the benchmark royalty rate is given by $\frac{1-\theta}{\theta}$. For an ironclad patent, $\theta = 1$, there is no overcharge at all, because there is no element of holdup at all. However, some overcharge is inevitable if the downstream firm has any chance of winning the patent litigation. For example, if $\theta = 0.5$, the percentage overcharge is 100%, i.e., the negotiated royalty rate is twice the benchmark level. Likewise, if the patent is a bit weaker, say $\theta = 1/3$, the percentage overcharge is 200%, i.e., the negotiated royalty rate is three times the benchmark level. The intuition is that the accused infringer has chosen to give up without a fight, effectively agreeing to treat a possibly invalid patent as certainly valid, and so the chance that it would have invalidated the patent will not be reflected in the negotiated royalty.

More generally, if the patent is sufficiently weak, the downstream firm's optimal strategy if licensing negotiations break down will *not* be to design its product to avoid the patented feature, even if the downstream firm learns of the patent at an early date. Instead, the downstream firm will pursue a version of the Litigate strategy, with the overcharges already discussed. In this case, early knowledge of the patent provides no benefit whatsoever to the downstream firm.[26] Indeed, because of patent damages rules for willful infringement, early knowledge of a weak patent may actually make the downstream firm worse off.[27]

The fact that early disclosure does not solve the holdup problem has some important implications. In a standard-setting context, for example, downstream firms are not protected from holdup by the owners of weak patents, even if those patents are disclosed before the standard is adopted and even if royalty negotiations can and do take place at that time.

F. Multiple Downstream Firms

Our analysis so far has focused on a single patent holder and a single downstream firm. Economic analysis of licensing negotiations is considerably more complex if there are multiple downstream firms. We are unaware of formal models that study injunctions, holdup, and patent

26. In a more general model, where the downstream firm had additional design options, such as the ability to design the product to facilitate subsequent redesign, the downstream firm would value early awareness of the patent.

27. For an explanation of these rules, see, for example, Mark A. Lemley & Ragesh K. Tangri, *Ending Patent Law's Willfulness Game*, 18 BERKELEY TECH. L.J. 1085, 1087–88, 1100–02 (2003) (discussing the perverse situation where a company discourages its engineers from reading patents to avoid liability for willfulness).

licensing with multiple downstream firms. We can, however, indicate how the analysis just presented is affected by the presence of multiple downstream firms.

First, the benefits to the downstream firm of challenging the patent are reduced if it competes against other downstream firms who also use the patented technology.[28] Invalidating the patent benefits all of the downstream firms and typically will not give the downstream firm at issue a competitive advantage over its rivals. In fact, the invalidating firm has paid legal fees its competitors have not had to incur. This effect makes litigation less attractive to the downstream firm and thus tends to *raise* the negotiated royalty rate. Farrell and Shapiro show that this "public good" effect leads to overcharges for weak patents even if redesign is immediate and costless so there is no possibility of opportunism by the patent holder.[29]

Second, the costs to the patent holder of litigating against one downstream firm are increased by the risk that the patent holder's royalties from *other* downstream firms will be reduced or eliminated if it loses the patent litigation. This effect is larger the weaker the patent and arises whether or not the downstream firms compete against each other. This effect may arise if other firms have already signed licenses since they will no longer be obliged to pay royalties if the patent is found invalid.[30] However, the patent holder has the incentive to mitigate this risk by signing licenses that involve up-front payments that are not refundable if the patent is later found invalid. Even if running royalties are used, the patent holder can still mitigate this risk by signing licenses that are based in part on trade secrets or on a group of patents in its patent portfolio, and thus are protected from subsequent unfavorable patent rulings regarding any single patent.[31]

Licensees are likely to be amenable to these mitigation strategies. In equilibrium, if the parties consider it very unlikely that the patent will be litigated to final judgment—and recall that litigation to final judgment is rare

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28. *See* Joseph Farrell & Robert P. Merges, *Incentives to Challenge and Defend Patents: Why Litigation Won't Reliably Fix Patent Office Errors and Why Administrative Patent Review Might Help*, 19 BERKELEY TECH. L.J. 943, 958 (2004) (describing the public goods problem leading to undersupply of patent challenges); Joseph Scott Miller, *Building a Better Bounty: Litigation-Stage Rewards for Defeating Patents*, 19 BERKELEY TECH. L.J. 667, 687 (2004) (arguing that patent litigation jurisprudence "eliminates a patent attacker's ability to exclude others from appropriating the benefit of its successful patent attack"); Farrell & Shapiro, *supra* note 11, at 2 ("[I]ncentives [for downstream firms that compete] to challenge patents are sub-optimal . . . .").

29. Farrell & Shapiro, *supra* note 11, at 2.

30. *See* Blonder-Tongue Labs., Inc. v. Univ. of Ill. Found., 402 U.S. 313, 334 (1971) ("[I]t is insufficient in and of itself to justify patentees relitigating validity issues as long as new defendants are available."); Brulotte v. Thys Co., 379 U.S. 29, 32 (1964) ("[A] patentee's use of a royalty agreement that projects beyond the expiration date of the patent is unlawful *per se*.").

31. *See, e.g.*, Aronson v. Quick Point Pencil Co., 440 U.S. 257, 265–66 (1979) (upholding a continuing royalty obligation for trade secrets even after a patent application was rejected and the secret became public).

in patent cases as an empirical matter[32]—any one licensee will find it nearly costless to agree to conditions that only apply in the event that another firm successfully challenges the patent. In the case where the downstream firms are not rivals, or where the patent holder charges fixed fees rather than running royalties, these mitigation strategies clearly benefit the patent holder by placing it in a stronger bargaining position with other licensees in the future.[33] The mitigation strategies therefore raise the joint profits of the patent holder and the downstream firm in bilateral bargaining. Thus, bargaining theory predicts that in many settings the licensing agreements will preserve the patent holder's strength in subsequent negotiations. In fact, if the downstream firms are rivals, an early licensee will actually *benefit* from agreeing to conditions that will strengthen the patent holder's position in subsequent negotiations with other downstream firms, since the early licensee benefits if subsequent licensees (its rivals) must pay higher royalties. However, none of these mitigation strategies can protect the patent holder from the risk that it will lose the ability to sign licenses in the future for the patent in question with other downstream firms if its patent is invalidated.[34]

Third, the presence of additional downstream firms creates an additional *upside* to litigating for the patent holder, because the patent holder will be in a stronger position relative to these downstream firms if its patent is tested in court and upheld. This effect is larger the stronger the patent. However, this effect is delayed, going into effect only after a litigation victory.

Additional complexity arises if one takes account of differences among the downstream firms. For example, the patent holder may choose to go to trial early against a downstream firm that is in a relatively poor position to litigate. Or the patent holder might settle early with a downstream firm that possesses especially strong prior art on the condition that the downstream firm not disclose that prior art, thereby raising its effective patent strength vis-à-vis other downstream firms. A downstream firm may welcome this

32. *See, e.g.*, Jay P. Kesan & Gwendolyn G. Ball, *How Are Patent Cases Resolved? An Empirical Examination of the Adjudication and Settlement of Patent Disputes*, 84 WASH. U. L. REV. 237, 259 (2006) (finding that 80% of patent disputes settle); Mark A. Lemley, *Rational Ignorance at the Patent Office*, 95 NW. U. L. REV. 1495, 1501 (2001) (noting that the vast majority of patent disputes settle or are abandoned prior to trial).

33. When the downstream firms are rivals and the patent holder is charging running royalties (as distinct from fixed fees), the analysis is more complex. On the one hand, by protecting its running royalties in the event of an invalidity finding, the patent holder limits its downside, thereby making it more credible that the patent holder will in fact litigate rather than ignore an infringing firm and strengthening its bargaining position with any given downstream firm. On the other hand, if the patent holder will be able to continue to charge running royalties to other firms, even if one downstream firm successfully challenges the patent, the upside to a single downstream firm from litigating will be greater because winning the patent litigation will give that firm a competitive advantage over its rivals who will be paying higher running royalties.

34. An adverse decision on infringement or claim construction by one downstream firm may or may not have effects on royalties earned from other downstream firms, depending upon the similarity between the different downstream firms' products, and thus on the correlation between one downstream firm infringing and another doing so.

opportunity to strengthen the patent if it will subsequently be used against the downstream firm's rivals. Perhaps most significant, patentees have a choice of whether to pursue any of these strategies. If they are worried about the preclusive effect of a loss, they can sue all the defendants at once, eliminating the risk of inconsistent verdicts. It is not uncommon to see patent owners sue thirty or more defendants at the same time.

The economic literature on many of these points is in its infancy, and a thorough discussion of the strategic issues that arise when a single patent holder negotiates with multiple downstream firms, either simultaneously or sequentially, is beyond the scope of this Article. We do not know enough at this point to make general statements about just how the results reported above, based on a model with a single downstream firm, differ in the presence of multiple downstream firms. We can say, however, that if one downstream firm earns far greater revenues than the other downstream firms, our model of negotiations involving a single downstream firm will remain a very good guide to negotiations with that firm, even if other downstream firms are present.

G. Summary of Economic Theory

For weak patents, the downstream firm's optimal strategy tends to be Litigate. In this case, the negotiated royalty rate can be a large multiple of the benchmark level if the fraction of the product's value attributable to the patented feature is small. For stronger patents, or those weak patents that have the potential to hold up a large proportion of noninfringing contributions, the downstream firm's optimal strategy tends to be Redesign and Litigate. In this case, the negotiated royalty rate includes an overcharge based on the fact that the downstream firm incurs the redesign costs for sure if licensing negotiations break down, not just in the event that the patent is found valid and infringed. The negotiated royalty remains above the benchmark level even if the downstream firm is aware of the patent and is able to negotiate with the patent holder before the downstream firm initially designs its product, especially for weak patents.

H. Injunctions and Holdup in Practice

The potential for an injunction against a whole product can and does permit so-called patent trolls to hold up defendants by threatening to enjoin products that are predominantly noninfringing. As we have just shown, this threat can easily enable a patent holder to negotiate a settlement for an amount of money significantly exceeding the amount that the patent holder could expect to earn in damages based on reasonable royalties. In these cases it is not the underlying value of the patented technology, but the cost to the defendant of switching technologies midstream, that is driving the high royalties being paid.

This is not just a theoretical problem. In the real world, it is common for patent defendants to settle cases for more money than the patentee could have won in damages and license fees, simply to avoid the threat of an injunction shutting down the core product. For example, one patent owner charges a 0.75% royalty for patents that do not cover industry standards and 3.50% for patents that do cover industry standards.[35] The technology does not have any greater inherent value when used as part of an industry standard, but the patent holder can demand almost five times as much money once the industry has made irreversible investments. In another highly visible case involving the BlackBerry wireless email service, the threat of an injunction led to a settlement of $612.5 million, which was significantly more than the actual damages awarded by the jury.[36]

Not surprisingly, the possibility of revenue from such holdups has enticed a number of firms into the business, not of innovating, but of buying patents and suing to enforce them. Defining a patent troll has proven a tricky business, but that does not mean the problem does not exist. Nonpracticing entities file 30–40% of all patent suits in the computing and electronics industries, for example.[37]

Our analysis strongly supports the conclusion that holdup is of particular concern when the patent itself covers only a small piece of the product, as is common in the industries in which so-called patent trolls predominate. A microprocessor may include 5,000 different inventions, some made by the manufacturer and some licensed from outside. If a microprocessor maker unknowingly infringes a patent on one of those inventions, the patent owner can threaten to stop the sale of the entire microprocessor until it can retool its entire fab to avoid infringement. Small wonder, then, that patentees regularly settle with companies in the information technology industries for far more money than their inventions are actually worth. These companies are paying holdup money to avoid the threat of infringement. That is not a legitimate part of the value of a patent; it is a windfall to the patent owner that comes at the expense not of unscrupulous copyists but of legitimate companies doing their own R&D. Furthermore, proportionate

35. Mark R. Patterson, Commentary, *Antitrust and the Costs of Standard-Setting: A Commentary on Teece & Sherry*, 87 MINN. L. REV. 1995, 2001 n.33 (2003) (referring to the different royalties Rambus charged).

36. *See* NTP, Inc. v. Research in Motion, Ltd., No. Civ. A. 3:01CV767, 2003 WL 23100881, at *1 (E.D. Va. Aug. 5, 2003) (awarding reasonable royalty damages in the amount of about $33.5 million). The settlement was eighteen times the jury award. *See* Mark Heinzl & Amol Sharma, *Getting the Message: RIM to Pay NTP $612.5 Million to Settle BlackBerry Patent Suit*, WALL ST. J., Mar. 4, 2006, at A1. To be sure, the damages the jury awarded were only for six of fifteen remaining years on the patent, so adding a going forward royalty would presumably have raised the total award. And there is reason to believe RIM will sell more BlackBerries in the future than it has in the past. But even that continuing royalty would likely have been significantly less than the $612.5 million settlement that was reached in March 2006.

37. Mark A. Lemley et al., Tracking Patent Trolls (2007) (unpublished manuscript, on file with author).

royalty overcharge due to holdup is governed by factors other than the patent holder's actual innovative contribution (*M*, *C*, and *L* in the analysis above, not *V*), so permitting patent holders to engage in holdup is not an efficient way to reward innovation. Indeed, since the victims of holdup are frequently firms that have made significant R&D investments themselves, the patent system actually discourages innovation when it enables patent holdup.

The Federal Circuit has concluded that this "additional leverage in licensing" is "a natural consequence of the right to exclude and not an inappropriate reward" to a patentee.[38] We respectfully but vigorously disagree with the court. The leverage comes from the ability of a patent owner to capture value that has nothing to do with its invention. It results from the inability of the accused infringer to separate the infringing component from the noninfringing ones after the fact. There is no reason in law or policy to give such power to a patent owner. Doing so will encourage rent seeking by patent trolls and discourage innovation by firms that design and manufacture complex products; it can even lead to circumstances in which no one can profitably produce a product with social value.

III. Royalty Stacking and Holdup

In the last Part, we demonstrated that substantial holdup was a very real possibility even when there was only one patent asserted against a particular product. Under many plausible circumstances, the royalty negotiated in the shadow of litigation and holdup can significantly exceed the intrinsic value of the invention itself. We now discuss situations in which multiple patents read on a single product, so that the downstream firm must deal with the stacking of royalties paid to two or more patent holders.

Royalty stacking, patent thickets, and the related "anticommons" problem have been a source of concern in the semiconductor and biotechnology industries for some time.[39] While the precise extent of these problems remains unclear, empirical evidence has mounted that royalty stacking is far more than a theoretical possibility.[40]

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38. MercExchange, L.L.C. v. eBay, Inc., 401 F.3d 1323, 1339 (Fed. Cir. 2005), *vacated*, 126 S. Ct. 1837 (2006).

39. *See* Heller & Eisenberg, *supra* note 5, at 699 (warning against a potential "tragedy of the anticommons" in the biomedical industry that could deter innovation in the future); Shapiro, *supra* note 5, at 120 (expressing concern over the emergence of a "patent thicket," where "stronger patent rights can have the perverse effect of stifling, not encouraging, innovation").

40. For evidence of royalty stacking in the semiconductor industry, see Rosemarie Ham Ziedonis, *Don't Fence Me In: Fragmented Markets for Technology and the Patent Acquisition Strategies of Firms*, 50 MGMT. SCI. 804, 817–18 (2004) (finding that firms acquire patents more aggressively when the patents for numerous component technologies of an industry—like the semiconductor industry—are widely distributed). For evidence of royalty stacking in the software industry, see Michael Noel & Mark Schankerman, *Strategic Patenting and Software Innovation* 27 (Ctr. for Econ. Policy Research, Discussion Paper No. 5701, 2006) (finding "clear evidence that strategic patenting and technology spillover are present" in the software industry). Rebecca Eisenberg and Richard Nelson argue that patents on biomedical research tools can retard innovation.

Not surprisingly, the existence of such "royalty stacking" exacerbates the holdup problem. Simply as a matter of arithmetic, the problems noted above are greater when the downstream firm faces infringement claims from multiple patent owners. As a first approximation, the magnitude of the problem is multiplied by the number of patents that read on the product.

However, a closer look at the underlying economics reveals that the aggregate or stacked royalty rate is not simply the sum of the royalty rates that would be negotiated bilaterally by each patent holder in the absence of the other patent holders. Put differently, the royalty rate negotiated by one patent holder is affected by the rates the downstream firm pays to *other* patent holders, so a proper analysis must account for the joint determination of all the royalty rates. We have identified three reasons why the royalty rate paid to one patent holder on a given product is affected by the rates paid to the holders of other patents reading on that same product: (1) rent splitting, (2) shutdown, and (3) Cournot complements.[41]

First, bargaining theory, as used above, tells us that the downstream firm and a patent holder who are negotiating will split the additional profits (rents) that result from reaching a settlement rather than litigating. As emphasized above, litigation can lead to an injunction and the loss of profit margins by the downstream firm. The larger are the royalties that the downstream firm is paying to *other* patent holders, the smaller are the

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Rebecca S. Eisenberg & Richard R. Nelson, *Public vs. Proprietary Science: A Fruitful Tension?*, DAEDALUS, Spring 2002 at 89, 101 (stating that in the biomedical industry, "proprietary control of information can impose significant costs on subsequent research and thereby obstruct, rather than promote, product development"). However, John Walsh, Ashish Arora, and Wesley Cohen found that researchers found various ways to work around patents on research tools, including licensing, inventing around, and infringement; they did not find clear evidence that basic biomedical research has been stifled by patents on biomedical research tools, but these results are significantly attributable to scientists simply ignoring patents. John P. Walsh, Ashish Arora & Wesley M. Cohen, *Working Through the Patent Problem*, 299 SCIENCE 1021, 1021 (2003) (concluding nevertheless that because "aggressive assertions of IP can still threaten scientific research," there is a "continuing need for active defense of open science"). Fiona Murray and Scott Stern find evidence of a modest anticommons effect using pairs of scientific articles and associated patents. Fiona Murry & Scott Stern, *Do Formal Intellectual Property Rights Hinder the Free Flow of Scientific Knowledge? An Empirical Test of the Anti-Commons Hypothesis* 31 (Nat'l Bureau of Econ. Research, Working Paper No. 11465, 2005) ("Overall, we are able to reject the null hypothesis that IP rights have no impact on the diffusion of scientific knowledge."). For a discussion of the role of patents and the danger of royalty stacking in biomedical research and in the software industry, see generally WENDY H. SCHACHT, CONGRESSIONAL RESEARCH SERVICE REPORT FOR CONGRESS, PATENT REFORM: ISSUES IN THE BIOMEDICAL AND SOFTWARE INDUSTRIES 12 (2006), *available at* http://www.fas.org/sgp/crs/misc/RL33367.pdf (discussing the sometimes divergent views of the biomedical and software industries toward patents and proposed patent reform), and INTELLECTUAL PROPERTY RIGHTS IN FRONTIER INDUSTRIES: SOFTWARE AND BIOTECHNOLOGY (Robert W. Hahn ed., 2005) (collecting essays addressing the pertinent policy debates surrounding patent issues in these fields).

41. Simple benchmarking could provide a fourth reason if the rate negotiated between the downstream firm and one patent holder is used as a benchmark in negotiations with other patent holders. However, for benchmarking to be important, the second patentee must have information about the negotiated rate, and the patents involved must be considered at least somewhat "comparable" by the negotiating parties.

margins on the downstream firm's product (the variable M in the analysis above), and the lower is the negotiated royalty rate. To put it bluntly, if the downstream firm is paying royalties to many other patent holders, its margin is reduced, making the threat of an injunction by any one patent holder less powerful.

Second, and related, some limits on the aggregate royalty burden arise because of the constraint that the downstream firm's margin cannot be driven below 0.[42] Unfortunately, however, this constraint does not prevent very substantial royalty overcharges, especially if the downstream firm must make substantial investments to design, manufacture, market, and sell its product. To illustrate, suppose that there are ten patent holders, with each patent covering a technology that adds V = \$1 in value to the downstream firm's product. Suppose that the downstream product sells for \$40 per unit and involves a cost of \$10 per unit before accounting for any patent royalties. So long as the aggregate royalty burden is less than the gross margin of \$30 per unit, the downstream firm will produce its product. Therefore, in a symmetric situation, each patent holder could obtain a royalty as high as \$3 per unit, or three times its underlying value, before the downstream firm would shut down. If the patents have, say, 40% strength, and if the bargaining skill is equal, then the benchmark royalty level would be $\theta \times B \times V = 0.4 \times 0.5 \times \$1.00$, or \$0.20. So each patent holder could charge fifteen times the benchmark royalty rate before the downstream firm would shut down.[43] In this example, if royalties were at their benchmark level of \$0.20 per patent, or \$2.00 in total, the downstream firm's margin after accounting for royalties would be \$28.00 per unit. These margins may be critical to providing the downstream firm a reasonable return on its own investments in R&D, manufacturing, and marketing. In the long run, if products are expected to be subject to some degree of holdup, the firm may not find it worth incurring the costs necessary to develop, manufacture, and sell the product. Assertions based on the shut-down condition that royalty stacking is somehow a minor problem or that royalty stacking cannot stifle innovation or hinder the market penetration of products that have been developed are simply unfounded.

The fact that royalties from all the patents reading on a single product must be added up is one reason why we focused on the *percentage overcharge* associated with each patent. Perhaps it seems like a relatively small matter if the threat of holdup causes the downstream firm to pay a

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42. *See* Douglas Gary Lichtman, *Patent Holdouts and the Standard-Setting Process* 6–7 (Univ. of Chi. Law Sch., John M. Olin Law & Economics Working Paper No. 292, 2006), *available at* http://www.law.uchicago.edu/Lawecon/WkngPprs_251-300/292.pdf (noting that a larger number of overlapping patent holders can be a self-limiting problem because a larger number of patents means less money for each patent holder).

43. Of course, in practice, higher royalty burdens will lead to higher prices and reduced output, with associated deadweight loss. Accounting for these effects, while complicating the math, strengthens our argument.

royalty equal to $1.00 per unit to a single patent holder, rather than the benchmark level of $0.20 per unit. But royalties that are five times their benchmark level can have dramatic effects if these royalties are due not just for one patent but for many patents. With the recent surge in patenting,[44] especially in the information technology industry where royalty stacking is a serious concern,[45] these overcharges, when aggregated, can lead to a very significant cost burden on producers. If these royalties accurately reflected the contributions made by the patent owners, the additional cost is one producers should be made to bear in order to encourage innovation. However, by focusing above on the gap between the negotiated royalty and the benchmark level, we have already shown that much of this cost burden is *not* justified based on the actual contributions of the patent holders who earn these royalties.

Third, a complete analysis should account for the fact that higher running royalties will raise the downstream firm's marginal cost, which will raise its price and thus reduce its level of output. This is an example of the effect well known to economists under the label of "Cournot complements." The Cournot-complements effect arises when multiple input owners each charge more than marginal cost for their input, thereby raising the price of the downstream product and reducing sales of that product.[46] Effectively, each input supplier imposes a negative externality on other suppliers when it raises its price, because this reduces the number of units of the downstream product that are sold. As a result, if multiple input owners each control an essential input and separately set their input prices, output is depressed even below the level that would be set by a vertically integrated monopolist.[47] The theory of Cournot complements teaches us that the royalty stacking problem is likely to be worse the greater the number of independent owners of patents that read on a product.

Unfortunately, the stacking of running royalties for a product sold at a positive margin by the downstream firm combines the inefficiencies

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44. U.S. PATENT & TRADEMARK OFFICE, U.S. PATENT ACTIVITY CALENDAR YEARS 1790 TO THE PRESENT (2006), http://www.uspto.gov/web/offices/ac/ido/oeip/taf/h_counts.pdf (providing a table that shows the number of patents more than tripled between the years 1980 and 2005); Mark A. Lemley & Bhaven Sampat, Is the Patent Office a Rubber Stamp? (2007) (unpublished manuscript, on file with author) (finding that modern patent applications are filed disproportionately in the information technology industries).

45. *See, e.g.*, Mark A. Lemley, *Ten Things To Do About Patent Holdup of Standards (And One Not To)*, 48 B.C. L. REV. 149, 151 (2007) (stating that IT products are often covered by numerous patents because they are technologically complex and integrate many components).

46. Cournot used the example of copper and zinc suppliers selling to manufacturers of brass. AUGUSTIN COURNOT, RESEARCHES INTO THE MATHEMATICAL PRINCIPLES OF THE THEORY OF WEALTH 99–116 (Nathaniel T. Bacon trans., Augustus M. Kelley Publishers 1971) (1838).

47. For a derivation of this well-known result, see Shapiro, *supra* note 5, app. In the special case of constant elasticity demand for the final product, if there are N essential inputs, each controlled by a single firm, and if the downstream firm(s) simply price at their marginal cost, the resulting markup on the final good, i.e., the percentage gap between price and the true marginal cost of producing that good, is N times the monopoly level.

associated with two well-known pricing problems in industrial organization: "double marginalization," which arises when input suppliers with market power (here, the patentees) sell to a downstream firm that also has some power over price, and the Cournot-complements effect, which arises when multiple suppliers with market power sell complementary products.[48] Together, these problems cause prices to be *higher* than would be set by an integrated monopolist who owned all of the patents and sold the downstream product.

According to the general theory of Cournot complements, the equilibrium level of output by the downstream firm tends to be smaller the more fragmented the ownership of a given set of patents that read on the downstream product. As an illustration, Appendix A considers situations in which the constraint on the royalty set by each of N patent holders is based on the reduction in output associated with higher royalty rates (and not by the downstream firm's threat to shift to a substitute of the patented technology).[49] As shown in Appendix A, if marginal costs are constant and the downstream firm faces linear demand, the output level if N essential patents are owned by N separate firms is equal to the output level if all N patents were owned by a single firm multiplied by the factor $\frac{2}{N+1}$. For example, with three patents held by separate firms, downstream output is half as much as it would be if a single company owned all three patents.

As is usual with Cournot complements, there is an incentive for the patentees to coordinate to reduce their royalties, e.g., by engaging in cross licenses or by licensing their patents in a pool at an agreed-upon rate.[50] However, the negotiations necessary to form such a pool can be very thorny if there are many firms involved, since each may be tempted to opt out of the pool and assert its patents separately. Indeed, it may be very difficult to induce patentees who are not themselves producers in the market to join a patent pool. Such a patent holder might well maximize its revenues by staying out of a proposed patent pool and asserting its patent rights independently, unless it believes that its failure to join the pool will undermine the formation of the pool and thus seriously hinder sales of the

48. Formally, these two problems are very similar; both involve multiple markups in the value chain, set in an uncoordinated fashion. While double marginalization refers to situations in which there are two such markups, with royalty stacking the number of markups can be much larger.

49. This is a fundamentally different approach than the one taken in the text above, where the downstream firm's threat was either to litigate the patent or redesign its product to avoid infringing, and the output by the downstream firm was fixed. The analysis in Appendix A thus complements that provided in the text above.

50. Baker and Lichtman have suggested contractual mechanisms by which this might be accomplished. Scott Baker & Doug Lichtman, Discouraging Patent Holdouts Through Reciprocal Commitment 15–25 (Nov. 27, 2006) (unpublished manuscript), *available at* http://www.law.northwestern.edu/colloquium/law_economics/lichtman.pdf.

product in question.[51] Negotiations are even harder if several of the patentees hold multiple patents, and if the relevant patents vary greatly in scope and strength. Of course, patent pools do sometimes overcome these obstacles and successfully form. We simply note that the transaction costs can be substantial and that the presence of nonmanufacturing patent owners makes the formation of successful pools harder.

Even if firms do not enter into cross licenses or form patent pools, they may be able partially to protect themselves from holdup by threatening a reciprocal patent infringement action if accused of infringing the patent held by another manufacturer. Ziedonis finds evidence that semiconductor firms acquire patents more aggressively if the rights to patents complementary to the firm's products are widely distributed among outside parties, which is precisely when royalty stacking is expected to cause the greatest problems.[52] She also finds that the enhanced propensity to patent arising when technology markets are fragmented is most pronounced among firms that have made large investments in technology-specific assets, i.e., the firms most vulnerable to holdup.[53] Furthermore, she finds that these effects became larger when the legal regime strengthened the exclusionary rights of patent holders.[54] Importantly, however, this counterstrategy cannot be employed against those nonpracticing patent holders sometimes called patent trolls. Not surprisingly, therefore, in industries facing significant royalty stacking, more than a third of all patent suits are filed by such nonpracticing entities.[55]

The theory of Cournot complements warns us that royalty stacking causes harm based on reduced output, higher prices, and thus deadweight loss. Recent empirical evidence seems to confirm this result and to suggest that both greater fragmentation and uncertainty about rights aggravate the problem.[56] Furthermore, if anticipated, the combined royalty burden

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51. Anne Layne-Farrar and Josh Lerner examine the decisions by patent holders whether or not to participate in nine specific patent pools, eight of which grew out of standard-setting efforts. Anne Layne-Farrar & Josh Lerner, To Join or Not to Join: Examining Patent Pool Participation and Rent Sharing Rules 7 (Nov. 15, 2006) (unpublished manuscript), *available at* http://ssrn.com/abstract=945189. They find that as many as one-half to two-thirds of the eligible members chose not to participate in some patent pools. *Id.* at 23. Often, nonparticipants held relatively few patents and thus appear to have elected to assert their patents independently, perhaps engaging in holdup, rather than accepting a relatively small share of the royalties collected by the pool. *Id.* at 32 tbl.1. This finding is consistent with the analysis of Reiko Aoki and Sadao Nagaoka. Reiko Aoki & Sadao Nagaoka, *Coalition Formation for a Consortium Standard Through a Standard Body and a Patent Pool: Theory and Evidence from MPEG2, DVD and 3G* 4–11 (Hitotsubashi Univ. Inst. of Innovation Research, Working Paper No. 05-01, 2005), *available at* http://www.iir.hit-u.ac.jp/event/WP05-01aoki,%20nagaoka.pdf.

52. Ziedonis, *supra* note 40, at 813–15.

53. *Id.* at 805, 817.

54. *Id.* at 817.

55. Lemley et al., *supra* note 37.

56. *See* Ben Depoorter & Sven Vanneste, *Putting Humpty Dumpty Back Together: Pricing in Anticommons Property Arrangements* 6 (George Mason Univ. Sch. of Law, Working Paper No. 11, 2004), *available at* http://law.bepress.com/gmulwps/gmule/art11/ (measuring the pricing effect of uncertainty and fragmentation).

associated with royalty stacking may make it unprofitable for the downstream firm to conduct the R&D and incur the other costs necessary to develop the product in question. While no individual patent holder benefits from this result, the net result of the royalties that each of them negotiates separately with the downstream firm can lead to this mutually unattractive outcome. Less dramatic versions of this effect can arise as well. For example, the downstream firm may not find it worthwhile to develop some versions of the product if the royalty burden prevents it from selling enough units at a large enough margin to recoup the additional development costs associated with those versions.

These problems of holdup and royalty stacking can be severe in the case of private standard setting. Indeed, the leading recent antitrust cases involving allegations of holdup by patent owners involve product standards.[57] In terms of the analysis already presented, the key point is that it can be extremely costly, or even impossible as a practical matter, to "redesign" a product standard to avoid infringing a patented technology, even if initially an alternative standard could easily have been selected. In the case of standards, such redesign actually involves going through some process by which the standard-setting organization (SSO) selects a new standard or modifies an old standard. These processes, which often rely on consensus, can be slow moving. Furthermore, if multiple manufacturers have begun selling products that comply with the initial standard, possibly including various complementary products associated with the standard, switching to a noninfringing design can be extremely costly and commercially infeasible. With very high redesign costs, we have already shown that the threat of an injunction can lead to large royalty overcharges, especially for weak patents.

There is a second reason why royalty stacking is especially problematic in the case of product standards: it is common for multiple companies to own patents covering essential aspects of product standards, at least for telecommunications and computer standards. The nature of the process by which standards are selected tends to involve consensus and compromise, leading to a product standard that reads on the patents of many firms. Each individual firm may place high value on having at least one patent that covers an essential feature of the standard, in part to strengthen its bargaining position vis-à-vis other companies who own essential patents. Tim Simcoe documents a

57. *See, e.g.*, Rambus, Inc. v. Infineon Techs. AG, 318 F.3d 1081 (Fed. Cir. 2003) (overturning a district court judgment of fraud against Rambus); *In re* Rambus, Inc., No. 9302, Opinion of the Commission (F.T.C. Aug. 2, 2006) (finding Rambus liable for monopolization for concealing the existence of patents in order to influence the standard selected by the Joint Electron Device Engineering Council); *In re* Union Oil Co. of Calif., No. 9305, 2004 WL 1632816, Order of the Commission (F.T.C. July 6, 2004) (reversing an administrative law judge's decision to dismiss an antitrust claim against Unocal, and remanding for trial before the administrative law judge); *In re* Dell Computer Corp., 121 F.T.C. 616 (May 20, 1996) (granting a consent decree prohibiting Dell from enforcing patent rights against computer manufacturers related to a technology Dell had failed to disclose to a standard-setting organization).

dramatic increase over the past fifteen years in the number of "essential patents" disclosed to standard-setting organizations.[58]

A final problem with royalty stacking has to do with the effects of multiple patents on the "design-around" alternative. In our model, the most significant factor limiting royalty overcharges was the availability of a noninfringing design-around. In a world with multiple patents, it is not necessarily the case that design-around alternatives will themselves be unpatented. If the alternatives available to the downstream firm may themselves be patented and lead to a holdup situation in the future, and if those uncertainties also cannot be resolved in advance, the bargaining outcome will include a more significant departure from the benchmark royalty rate than we have measured above.

IV. Reasonable Royalties

Our analysis so far has emphasized the problems that arise due to the patent holder's threat to obtain an injunction. However, there is a related set of problems that arises because of difficulties associated with the practical implementation of the concept of the reasonable royalties that an infringing firm owes the patent holder if the court finds that infringement has occurred.

So far, we have assumed that reasonable royalties were at the benchmark level of $\theta \times B \times V$. We now show why reasonable royalties tend to be higher than this benchmark level. We then explain how a higher level of reasonable royalties exacerbates the problems already identified based on injunctions and holdup.

A. Legal Standards for Reasonable Royalties

The patent statute provides that a patentee can recover its lost profits from infringement, if it can prove them, but is always entitled to no less than a reasonable royalty.[59] Lost profits are difficult to prove,[60] and any patent owner who does not sell goods in competition with the defendant will be unable to demonstrate lost profits from infringement. The only loss for such patent holders is the royalty for which they could have licensed the patent.

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58. Timothy S. Simcoe, Explaining the Increase in Intellectual Property Disclosure (Dec. 8, 2005) (unpublished manuscript), *available at* http://www.rotman.utoronto.ca/timothy.simcoe/papers/SSO_IPR_Disclosures.pdf.

59. 35 U.S.C. § 284 (2000). For a detailed discussion of the history of patent damages, see Amy L. Landers, *Let the Games Begin: Incentives to Innovation in the New Economy of Intellectual Property Law*, 46 SANTA CLARA L. REV. 307, 311–22 (2006).

60. The basic test is set out in *Panduit Corp. v. Stahlin Bros. Fibre Works*, 575 F.2d 1152 (6th Cir. 1978). Under *Panduit*, the patentee must show demand for the patented product, the absence of noninfringing substitutes, the patentee's ability to meet the demand for the infringing goods, and the amount of profit the patentee would have made from those sales. *Id.* at 1156. The Federal Circuit has adopted this test. *See* Hebert v. Lisle Corp., 99 F.3d 1109, 1119–20 (Fed. Cir. 1996); State Indus., Inc. v. Mor-Flo Indus., Inc., 883 F.2d 1573, 1577 (Fed. Cir. 1989).

How does a court determine what royalty is reasonable? In a case called *Georgia-Pacific v. United States Plywood*,[61] the court set out a detailed test designed to emulate the bargain the parties would have entered into at the time infringement began had they (1) been willing to negotiate and (2) known to a certainty that the patent was valid and infringed.[62] While *Georgia-Pacific* identified fifteen different factors,[63] in fact they collapse into only three significant issues: the significance of the patented invention to the product and to market demand, the royalty rates people have been willing to

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61. 318 F. Supp. 1116 (S.D.N.Y. 1970).

62. *Id.* at 1121–22.

63. Those factors are:

> 1. The royalties received by the patentee for the licensing of the patent in suit, proving or tending to prove an established royalty.
> 2. The rates paid by the licensee for the use of other patents comparable to the patent in suit.
> 3. The nature and scope of the license, as exclusive or nonexclusive; or as restricted or nonrestricted in terms of territory or with respect to whom the manufactured product may be sold.
> 4. The licensor's established policy and marketing program to maintain his patent monopoly by not licensing others to use the invention or by granting licenses under special conditions designed to preserve that monopoly.
> 5. The commercial relationship between the licensor and licensee, such as, whether they are competitors in the same territory in the same line of business; or whether they are inventor and promoter.
> 6. The effect of selling the patented specialty in promoting sales of other products of the licensee; the existing value of the invention to the licensor as a generator of sales of his nonpatented items; and the extent of such derivative or convoyed sales.
> 7. The duration of the patent and the term of the license.
> 8. The established profitability of the product made under the patent; its commercial success; and its current popularity.
> 9. The utility and advantages of the patent property over the old modes or devices, if any, that had been used for working out similar results.
> 10. The nature of the patented invention; the character of the commercial embodiment of it as owned and produced by the licensor; and the benefits to those who have used the invention.
> 11. The extent to which the infringer has made use of the invention; and any evidence probative of the value of that use.
> 12. The portion of the profit or of the selling price that may be customary in the particular business or in comparable businesses to allow for the use of the invention or analogous inventions.
> 13. The portion of the realizable profit that should be credited to the invention as distinguished from nonpatented elements, the manufacturing process, business risks, or significant features or improvements added by the infringer.
> 14. The opinion testimony of qualified experts.
> 15. The amount that a licensor (such as the patentee) and a licensee (such as the infringer) would have agreed upon (at the time the infringement began) if both had been reasonably and voluntarily trying to reach an agreement; that is, the amount which a prudent licensee—who desired, as a business proposition, to obtain a license to manufacture and sell a particular article embodying the patented invention—would have been willing to pay as a royalty and yet be able to make a reasonable profit and which amount would have been acceptable by a prudent patentee who was willing to grant a license.

Id. at 1120.

pay for this or other similar inventions in the industry, and expert testimony as to the value of the patent.[64]

While the stated goal of the reasonable-royalty inquiry is to replicate the negotiation that might otherwise have occurred, it is important to recognize that the negotiation is counterfactual in important respects. First, and most obviously, the parties did *not* agree beforehand. If a court is calculating damages, the parties litigated the case all the way through trial, at an expense of many millions of dollars per side in legal fees and great time and effort.[65] There is likely a reason they did not agree and fought the case to a conclusion without settling. Assuming that they did settle necessarily elides whatever factors (competition between the parties, the effect of a deal on other licensees, disagreements over the merits of the claim, or—most significant—the possibility that the patentee stood to lose more than the defendant had to gain from licensing, so that no deal was rational)[66] prevented a deal in the first place. It also prevents a patent owner from structuring royalty rates by giving a price break to those who settle easily,[67] and indeed encourages the opposite—trying to establish royalty rates for subsequent litigation by creating a record of high royalty rates in early negotiations.[68] Second, the *Georgia-Pacific* factors assume that the parties know the patent is valid and infringed.[69] That makes some sense, as by the time we determine damages we know that it is. But it is highly counterfactual. As we have explained elsewhere, patents are probabilistic rights.[70] Nearly half of all litigated patents are invalidated, and many more are found not to be infringed.[71] Any

64. *See* Nickson Indus., Inc. v. Rol Mfg. Co., 847 F.2d 795, 798 (Fed. Cir. 1988) (relying on established market royalties as the strongest evidence of what royalty is reasonable); *see also* BLAIR & COTTER, *supra* note 14, at 228–29 (noting that courts focus on only a small number of the *Georgia-Pacific* factors, particularly other royalty rates in the industry).

65. *See* AM. INTELLECTUAL PROP. LAW ASS'N, REPORT OF THE ECONOMIC SURVEY 2005, at 22 (2005) (reporting in 2005 that patent litigants spent $4.5 million per side in legal fees in cases where more than $25 million was at stake).

66. On this last possibility, see BLAIR & COTTER, *supra* note 14, at 231–32. One example is *Golight, Inc. v. Wal-Mart Stores*, 355 F.3d 1327, 1338 (Fed. Cir. 2004), where the court upheld a reasonable royalty that exceeded the infringer's profits from the product. *See also* Monsanto Co. v. Ralph, 382 F.3d 1374, 1384 (Fed. Cir. 2004) (upholding a reasonable royalty that was several times both plaintiff's lost profits and defendant's gains). Obviously, the parties had no room to come to a deal in those situations.

67. Whether this is a good or a bad thing is unclear. There is some logic to requiring those who put a patentee to great time and expense to collect royalties to pay a higher rate than those who agree to license a patent quickly. On the other hand, such a tiered system may encourage too many people to settle, leading to underprovision of the public good of invalidating bad patents. On this public good, see, for example, Farrell & Merges, *supra* note 28; Miller, *supra* note 28; Farrell & Shapiro, *supra* note 11, at 18.

68. For evidence of analogous conduct in copyright arbitrations, see Thomas Nachbar, *Monopoly, Mercantilism, and Intellectual Property* 67–70 (Berkeley Ctr. for Law & Tech., Paper No. 9, 2005), *available at* http://repositories.cdlib.org/bclt/lts/9/.

69. *See* BLAIR & COTTER, *supra* note 14, at 229–30.

70. Lemley & Shapiro, *supra* note 25.

71. *See* John R. Allison & Mark A. Lemley, *Empirical Evidence on the Validity of Litigated Patents*, 26 AIPLA Q.J. 185, 205 (1998) (finding that 46% of patents litigated to judgment are

deal that occurs before or even during litigation will reflect the significant chance that the patent would ultimately be invalidated or that the defendant would be held not to infringe. As a result, royalty rates awarded in court under *Georgia-Pacific* properly should systematically exceed the rates that parties would negotiate out of court.[72] Courts have recognized this problem and periodically seek to modify the market-based royalty data by adding "kickers," either expressly or *sub rosa*.[73]

B. Practical Problems with Court-Determined Royalty Rates

Patent damages law theoretically recognizes that royalties should be based on the value of the patented feature, not the entire value of the product containing that feature, by calibrating the royalty to the importance of the inventor's contribution. Patents covering one small component of the larger invention are supposed to get lower royalty rates, measured as a fraction of the downstream selling price, than patents covering the whole product.[74] Indeed, the *Georgia-Pacific* test includes several factors that might permit courts to take account of the relative value of the patented component to the infringing product.[75] And the Supreme Court long ago recognized the problem of awarding patentees damages based on an entire product when

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invalidated); Kimberly A. Moore, *Judges, Juries, and Patent Cases—An Empirical Peek Inside the Black Box*, 99 MICH. L. REV. 365, 390 tbl.4 (2000) (finding that 35% of patents litigated to judgment are not infringed). Because patentees must win on all issues to prevail, they ultimately win only a small pereentage of cases—24% in the Federal Circuit. Paul M. Janicke & LiLan Ren, *Who Wins Patent Infringement Cases?*, 34 AIPLA Q.J. 1, 8 tbl.1 (2006).

72. *See* John J. Barnhardt, III, *Revisiting a Reasonable Royalty as a Measure of Damages for Patent Infringement*, 86 J. PAT. & TRADEMARK OFF. SOC'Y 991, 1001–02 (2004) (discussing the effect created by the knowledge of subsequent events in the hypothetical "reasonable royalty" negotiation); Edward F. Sherry & David J. Teece, *Royalties, Evolving Patent Rights, and the Value of Innovation*, 33 RES. POL'Y 179, 183 (2004) ("[A] proven-valid-and-infringed patent is a different, and more valuable, economic commodity than 'the same' patent for which the issues of validity and infringement have not yet been resolved.").

73. The Federal Circuit has rejected the affirmative use of a multiplier to enhance damages. *See* Mahurkar v. C.R. Bard, Inc., 79 F.3d 1572, 1580–81 (Fed. Cir. 1996) (rejecting the use of a "kicker" to enhance reasonable royalty damages to account for litigation costs). But there is reason to believe that courts engaged in such enhancements anyway by manipulating their findings on the appropriate royalty rate. *See* Monsanto Co. v. Ralph, 382 F.3d 1374, 1382–84 (Fed. Cir. 2004) (affirming the use of a multiplier to enhance the royalty rate); Landers, *supra* note 59, at 307; *see also* King Instruments Corp. v. Perego, 65 F.3d 941, 951 n.6 (Fed. Cir. 1995) (approving of "discretionary increases" in the royalty rate); Stickle v. Heublein, Inc., 716 F.2d 1550, 1563 (Fed. Cir. 1983) (contemplating an "increase" in the reasonable royalty rate to ensure that damages are adequate to compensate patentees). Landers is troubled by this, but in our view it can sometimes be appropriate to compensate for the differences between the circumstances of market and judicial royalty setting.

74. *See* Donald S. Chisum, *Reforming Patent Law Reform*, 4 J. MARSHALL REV. INTELL. PROP. L. 336, 347 (2005) ("If a royalty is based on the whole product rather than the part, the appropriate royalty rate should be correspondingly low.").

75. *See* Georgia-Pacific Corp. v. U.S. Plywood Corp., 318 F. Supp. 1116, 1120 (S.D.N.Y. 1970) (discussing factors six (value of the invention in generating derivative or convoyed sales), nine (advantages of the patent over old modes and devices), and thirteen (portion of profit credited to the invention)).

more than one inventor contributed components to that product. It would be "very grave error," the Court explained, "to instruct a jury that as to the measure of damages the same rule is to govern, whether the patent covers an entire machine or an improvement on a machine."[76]

This fundamental principle is reflected in the benchmark level of reasonable royalties we introduced above, $B \times V$, which is based on the value of the patented feature and *not* the price of the entire downstream product, P, or the margin earned on that product, M, which can be far larger. Consider our numerical example in which the price of the product is $P = \$40$ and the value of the patented feature is $V = \$1$. With equal bargaining skill, the benchmark level of reasonable royalties is $0.50 per unit. However, in practice, the value of the patented feature, V, is difficult for courts to observe, and royalty rates are typically quoted as a fraction of the price of the product containing the patented feature. This practice mathematically links the per-unit dollar royalty to the price of the entire downstream product. While a royalty that is a "mere" 2% or 3% of the product price might seem "reasonable" for a patented feature, in this numerical example these correspond to royalty rates of $0.80 or $1.20 per unit, roughly twice the benchmark level.

There are a number of theoretical and practical difficulties with judicial efforts to compensate for the existence of unpatented features of the invention. Those difficulties tend to drive royalty rates up, above the benchmark level, and cause courts in component cases to overreward patentees.

The first problem comes from reliance on industry licensing rates. While an effort by courts to mimic the market seems unexceptional,[77] in fact reliance on private license deals involves a degree of circularity because the royalty rates in those deals are themselves set as a function of what patentees could get if they went to court.[78] Our previous analysis of holdup abstracted away from this problem by assuming that infringement damages would be based on reasonable royalties set at the benchmark level of $B \times V$. Shapiro shows what happens when the courts base reasonable royalties on royalty rates negotiated by private parties, even though private parties negotiate those royalties in the shadow of litigation, and thus are influenced by the

76. Seymore v. McCormick, 57 U.S. 480, 491 (1853); *see also* Westinghouse Elec. & Mfg. Co. v. Wagner Elec. & Mfg. Co., 225 U.S. 604, 614–15 (1912) ("[The] invention may have been used in combination with valuable improvements made, or other patents appropriated by the infringer, and each may have jointly, but unequally, contributed to the profits. In such case, if plaintiff's patent only created a part of the profits, he is only entitled to recover that part of the net gains.").

77. *See* LAWRENCE M. SUNG, PATENT INFRINGEMENT REMEDIES 281 (2003) (calling such evidence "one of the strongest measures of a reasonable royalty").

78. To the extent court decisions determine royalty rates based on other court decisions setting royalty rates in the same industry, of course, the circularity is even more obvious, since whatever court sets the first rate will end up influencing all subsequent rates.

level of court-awarded reasonable royalties.[79] The consequence of this circularity is that reasonable royalties are elevated above the benchmark level, and the problems of holdup identified earlier "infect" the court-awarded level of reasonable royalties. Since negotiated royalties reflect a premium based on holdup, so will the reasonable royalties awarded by the court. And this in turn gives patent holders more negotiating power in a self-reinforcing manner, which ultimately magnifies the effects of holdup on negotiated royalty rates.[80]

A second problem comes from the source of available information about industry royalty rates. For obvious reasons, we rely on expert testimony to establish what the actual royalty rates are in any given industry. Those experts in turn must collect royalty data from nonlitigated transactions in the industry. But most of those transactions are confidential. As a result, experts regularly look either to heuristics or idiosyncratic transactions about which they happen to have information that can be disclosed in court,[81] or more commonly, they turn to established collections of publicly available royalty rates.[82] Those sources in turn acquire their data from the only place they can—the subset of license transactions that are available to the public. But that subset is not random. The most significant source of public patent licenses is federal securities law filings, which require disclosure of a patent license or settlement if it is material to the bottom line of either party.[83] Not surprisingly, license agreements that involve the payment of a large sum of money are more likely to be material—and therefore more likely to show up in a public database—than license agreements that involve a small payment, a walkaway, or a cross license. Thus, as a practical matter, expert testimony about royalty rates overstates those rates because the royalties that are reported tend to be higher than the average royalty. This too tends to drive court-awarded royalties above the benchmark level. Because of the

79. Theoretically, this circularity is resolved using the established concept of a self-fulfilling equilibrium. Logically, taking as given the level of reasonable royalties that the court would award, one calculates the negotiated royalty rate. Using the court's rule relating reasonable royalty awards to the royalty rates negotiated voluntarily, one then solves for the equilibrium royalty rate and level of reasonable royalties that are consistent with each other, or self-fulfilling.

80. These magnification effects are greatest if the patent litigation would take a large fraction of the time remaining in the patent lifetime. As the time required for litigation approaches the remaining patent lifetime, the circularity between the negotiated royalty rate and the level of reasonable royalties awarded by the court becomes complete.

81. For example, Amy Landers documents the existence of a 25% "rule of thumb" among patent damages experts. Landers, *supra* note 59, at 332–33; *see also* Ted Hagelin, *Valuation of Patent Licenses*, 12 TEX. INTELL. PROP. L.J. 423, 425–29 (2004) (discussing the limitations of the 25% rule and the problems involved in valuing patent licenses). For an apt characterization of that rule as "unreasonable," see Gregory K. Leonard & Lauren J. Stiroh, *A Practical Guide to Damages*, *in* ECONOMIC APPROACHES TO INTELLECTUAL PROPERTY POLICY, LITIGATION, AND MANAGEMENT 27, 49 fig.5, 50–52 (Gregory K. Leonard & Lauren J. Stiroh eds., 2005).

82. One major source of such data is RoyaltySource, http://www.royaltysource.com.

83. SEC Rule 10b-5, 17 C.F.R. § 240.10b-5 (2007).

circularity discussed above, it further contributes to higher royalty rates in patent settlements.

The third problem results from efforts to determine a reasonable royalty for a component not as a percentage of the sale of the component, but instead as a percentage of the sale of the whole product of which the component is a part. For obvious reasons, this issue is greatest in component industries, where *P* and *V* can differ very sharply in magnitude. Sometimes it can be avoided even in those industries, if the value of the patented component can be determined separately.[84] But in many cases, there is no obvious alternative to calculating patent damages using a royalty on the sale of the integrated product.[85] In theory, this doesn't present a problem; the fact finder will simply determine the portion of the value of the entire product that is attributable to the patentable component and reduce the royalty percentage accordingly.[86] In practice, however, things are more complicated. To begin, the "entire market value" rule imported from the lost profits cases will sometimes permit patentees to recover not just the value of the patented component but also other unpatented components of the product to the extent that demand for the patented piece drove sales of the whole device.[87] This rule makes sense so long as it is in fact the patented component that is responsible for the value of the whole invention, i.e., if *V* really is such a significant portion of *P* that it is the cause of the consumer purchasing the product.[88] Unfortunately, courts have on occasion applied the entire market value rule outside that context, finding it sufficient that the patented component was functionally interrelated with other components and made a

84. For example, in *Railroad Dynamics, Inc. v. A. Stucki Co.*, 727 F.2d 1506, 1518–20 (Fed. Cir. 1984) the patented component of a rail freight car was sold separately, so while it was a component of the larger invention the court could set the royalty as a percentage of the separate sale.

85. *See* BLAIR & COTTER, *supra* note 14, at 215–17 (discussing the problems with apportionment and citing cases calculating reasonable royalty using the entire market value rule).

86. For example, courts applying the *Westinghouse* standard discussed above did exactly that for many years. *See, e.g.*, Velo-Bind, Inc. v. Minn. Mining & Mfg. Co., 647 F.2d 965, 972–73 (9th Cir. 1981).

87. The leading case on the entire market value rule is *Rite-Hite Corp. v. Kelley Co.* 56 F.3d 1538, 1549–50 (Fed. Cir. 1995) (holding that the entire market value rule requires the unpatented components of a product to function together with the patented components of the product to produce a desired end result); *see also* King Instruments Corp. v. Perego, 65 F.3d 941, 950 n.4 (Fed. Cir. 1995) (explaining that the entire market value rule recognizes that the value of a patent may be higher than the value of the sales of the patented part alone); Hem, Inc. v. Behringer Saws, Inc., No. 00-CV-0331, 2003 WL 2321378, at *3 (N.D. Okla. July 30, 2003) (applying the entire market value rule to find that unpatented saws functioned with patented feed tables to produce a desired end result).

88. *See* Fonar Corp. v. Gen. Elec. Co., 107 F.3d 1543, 1552 (Fed. Cir. 1997) (stating that the entire market value rule should be applied only "when the patented feature is the basis for customer demand for the entire machine").

substantial contribution to the value of the whole invention.[89] This is the wrong standard because it allows one patentee to capture the entire value of an invention that may also be subject to claims by other patentees or based on other inputs, investments, or innovations made by the firm selling the product.[90]

Most component cases will have this characteristic; the value of the patent will be only a small part of the larger product. In such cases, in order to determine the right proportion of the value of the overall product, and therefore the right royalty rate measured as a fraction of the price of the downstream product, a court will have to determine what else is in the product besides the patented invention and how much those elements contribute to the value of the entire product.[91] Doing this might require, among other things, economic evidence or consumer surveys demonstrating how people value particular attributes of the product, along with evidence about substitutes for the patented component. Practically, it is not clear that parties have either the ability or the incentive to introduce evidence that *other* patented components contribute to a product's success. Certainly we rarely see such evidence introduced in actual cases. The patentee will not introduce such evidence because it would only reduce the royalty rate. The accused infringer often will not introduce it because that firm does not want to admit that it might be infringing other patented inventions.[92] Even if the accused infringer tries to do so, courts do not want to admit such evidence because it will require collateral litigation during the damages phase over the existence and value of parts of the product that are not covered by the patent at trial. In

89. *See* Bose Corp. v. JBL, Inc., 274 F.3d 1354, 1361 (Fed. Cir. 2001) (explaining that the entire market value rule is appropriate when the patent-related feature is the basis for customer demand).

90. The Federal Circuit acknowledged that royalty stacking may influence the hypothetical negotiation between the parties in *Integra Lifesciences I, Ltd. v. Merck KGaA*, 331 F.3d 860, 871–72 (Fed. Cir. 2003), *rev'd on other grounds*, 545 U.S. 193 (2005). For criticism of the entire market value rule, see Brian Love, *Patentee Overcompensation and the Entire Market Value Rule*, 60 STAN. L. REV. (forthcoming 2007).

91. Courts have on occasion engaged in such apportionment analysis. *See* Riles v. Shell Exploration & Prod. Co., 298 F.3d 1302, 1312 (Fed. Cir. 2003); Slimfold Mfg. v. Kinkead Indus., 932 F.2d 1453, 1458–59 (Fed. Cir. 1991); Procter & Gamble Co. v. Paragon Trade Brands, 989 F. Supp. 547, 612–13 (D. Del. 1997). But it is rare in modern damages case law. Blair and Cotter argue for abandoning any effort to apportion damages in component industry cases in favor of a slightly modified but-for causation test. BLAIR & COTTER, *supra* note 14, at 232–34. While in theory a causation analysis done under perfect information would account for the contributions of components other than the patented one to the success of a product, we fear that eliminating any direct consideration of noninfringing components will make it even harder than it currently is to calculate the contribution of the patented invention accurately. A causation analysis would also result in distributional inequities, since only one patent could presumably be the cause of the success of the product. That patentee would capture the entire value of the product, and other patentees with lesser contributions would get nothing.

92. A possible exception arises in the standard-setting context, where a number of patent holders may already have declared that their patents are essential to the standard; see our case studies below in subpart V(A).

the absence of such evidence, it is reasonable to expect that the nominal ability of the law to adapt royalty rates to deal with multicomponent products will be seriously hampered, and that royalty rates for component products will not be significantly smaller than for more traditional inventions. If juries never get to hear about the other contributors to the total value of the product, it is hardly surprising that they are willing to award a sizeable royalty rate for a patent on the one component they do learn about. We test that hypothesis in the next Part.

Taken together, these effects related to reasonable royalties exacerbate the holdup problems we discussed in Parts II and III. Injunctions give patent owners in component industries the ability to demand a disproportionate share of the value of the integrated product. The fact that there are many different patent owners multiplies the problem and leads to inefficiently high total prices. The fact that the patentees can obtain royalties that exceed the value of their contribution to the product gives patentees still more bargaining leverage in settlement negotiations. It also means that solving the injunctions problem alone is not enough. Even without the threat of injunctions, problems in the calculation of damages can produce holdup.

V. Empirical Analysis of Royalty Stacking

In this Part, we turn from theory to empirical evidence. We first document examples of the royalty stacking problem outside the litigation context in the development of new technologies within a standard-setting organization. We then examine how courts have actually determined reasonable royalties and the extent to which existing legal measures are adequate to solve the royalty stacking problem.

A. Case Studies

1. 3G Cellular Technology.—Several standards are being developed for the next generation of cellular telephones. One important standard is 3GPP,[93] better known as WCDMA (Wideband Code Division Multiple Access), which involves descendants of GSM (Global Systems for Mobile Communications). A second important standard is 3GPP2,[94] better known as CDMA2000, which involves descendants of CDMA.

Goodman and Myers have carefully studied the patent situation surrounding these standards. They examined the patents and patent applications declared essential to 3G technology according to the Web sites of the European Telecommunications Standards Institute (ETSI) and two Japanese standards organizations, ARIB and TTC.[95]

93. 3GPP Home Page, http://www.3gpp.org.
94. 3GPP2 Home Page, http://www.3gpp2.org.
95. Goodman & Myers, *supra* note 4.

For WCDMA, based on reporting at ETSI, they identified 6,872 essential patents and patent applications at the beginning of 2004.[96] They reduce these to 732 "patent families," where the members of a family are patents obtained in different countries for a single invention prior to January 1, 2004.[97] For CDMA2000, based on reporting at ARIB and TTC, they identified 924 essential patents issued prior to February 5, 2004.[98] They reduce these to 527 patent families.[99] Of these, there is an overlap of 327 patent families that apply to WCDMA and CDMA2000.[100] The relevant patents are assigned to forty-one different companies, with four companies owning the rights to three-quarters of these essential patents: Qualcomm, Ericsson, Nokia, and Motorola.[101]

The full scope of the problem is likely even worse than these numbers suggest. These data only include patents declared essential by companies participating in these SSOs.[102] For example, Nortel has asserted to the U.S. Telecommunications Industry Association (TIA) that it has patents essential to CDMA2000 but has not listed its patents with the European and Japanese SSOs.[103] Similarly, Lucent has not identified its essential patents. Nor does this list include patents that are essential to earlier standards (GSM, TDMA, CDMA) that also may be essential to WCDMA or CDMA2000.[104] On the other hand, not all of these patents may in fact prove to be essential; some may just be commercially valuable and some may be commercially insignificant.[105]

It is not clear what the total cost of these stacked royalties is. We have seen estimates as high as 30% of the total price of each phone, but those were based on summing royalty demands before any cross-licensing negotiations began. Bekkers suggests that the cost of patent licenses for cell phone Internet functionality after cross-licensing offsets is in the range of 20% of the price of the entire phone.[106] And of course Internet functionality is only

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96. *Id.* at 2.
97. *Id.* at 3.
98. *Id.*
99. *Id.*
100. *Id.*
101. *Id.* at 4.
102. *Id.* at 6.
103. *Id.*
104. *Id.*
105. Goodman and Myers report on a technical study by Fairchild Resources International on whether the claimed patents truly are essential in the narrow sense that "every element of at least one claim must be practiced in order to implement the standard." *Id.* About 20% of the claimed essential patents were judged essential using this definition. *Id.* The patents judged essential in this study are assigned to twenty companies, nineteen for WCDMA and thirteen for CDMA2000, with twelve companies owning essential patents for both standards. *Id.* at 4–5.
106. Rudi Bekkers & Joel West, *The Effect of Strategic Patenting on Cumulative Innovation in UMTS Standardization* 22 (Dynamics of Insts. & Mkts. in Eur., Working Paper No. 9, Mar. 2006), *available at* http://ipr.dime-eu.org/node/144.

one feature contributing to the cost and value of the phone. Nokia sought unsuccessfully to cap royalties for Internet functionality at 5% of the price of the phone.[107] Thelander suggests that actual royalties may run 22.5% for the WCDMA technology, in addition to the 15–20% for GSM technology if the phone is dual band.[108] Critically, he also notes that these are just the royalties for companies who have identified their essential patents and excludes expected payments to important patent holders such as AT&T.[109]

2. Case Study: Wi-Fi.—The IEEE 802.11 family of standards describe technology for wireless local area networking. This technology is generally known as Wi-Fi. Here we provide some information on patents claimed to be essential to Wi-Fi.

Our primary source of information on Wi-Fi comes from the IEEE 802.11 Working Group. In accordance with IEEE patent policy, the IEEE requests "patent assurance letters" from members. Such letters must indicate either that the member will not enforce any present or future patents required to implement the relevant standard, or that the member will license any such patents on reasonable, nondiscriminatory terms. While there may exist holders of essential patents who do not participate in the IEEE standards process, these patent assurance letters provide an idea of the minimum number of patents claimed to be essential to the 802.11 standard and the number of companies holding such patents.[110]

As of March 14, 2006, the following companies listed specific patents or patent applications in their letters of assurance: Agere Systems (at least eight), Aironet Wireless Communications (one), Apple Computer (two or three), AT&T (twenty), CSIRO, Cisco Systems (at least fourteen), France Telecom (many), Golden Bridge Technology (two), Hitatchi (one), IBM (at least one), Intersil (at least four), Japan Radio Co. (eleven), Nokia (at least seven), Norand (two), Proxim (three), Spectrix (at least one), TDF (many), Toshiba (one), the University of California (three), and VDG.[111] In addition, the following large companies have provided letters of assurance but have not listed specific patent numbers: AMD, Broadcom, Ericsson, KDD, Lucent, Motorola, NEC, Novell, Philips Semiconductors, Qualcomm, Samsung, Sanyo, Sharp, Symbol Technologies, and Texas Instruments.[112] The size of those latter companies suggests that there are hundreds, perhaps even thousands more patents that must be licensed to practice 802.11.

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107. *Id.*

108. Michael W. Thelander, *The IPR Shell Game*, SIGNALS AHEAD, June 6, 2005, at 1, 7.

109. *Id.*

110. IEEE Standards Ass'n, 802.11 Patent Letters of Assurance (Feb. 21, 2007), http://standards.ieee.org/db/patents/pat802_11.html (listing information about patents and patent letters of assurance for the 802.11 standard and several of its amendments).

111. *Id.*

112. *Id.* We do not know how many patents these companies may assert as essential to the 802.11 standard. There are also more than a dozen smaller companies in this same category.

In addition to these companies, Speedus Corp. claims an essential patent (No. 5,949,793) relating to MIMO (multiple in, multiple out), a technology central to 802.11n.[113] According to Speedus: "We believe that it would be difficult for any wireless communications company to construct a system without using one or more of our patented technologies."[114] Reportedly, there are 634 U.S. patent applications and 255 patents granted by the U.S. Patent and Trademark Office (PTO) regarding MIMO.[115] In addition, there has been at least one concluded lawsuit involving the technology. In that case, Symbol Technologies was awarded a 6% royalty rate in a jury verdict on a single patent relating to the 802.11 standard.[116]

In an attempt to deal with the problem of patent stacking for 802.11 products, Via Licensing, a subsidiary of Dolby Laboratories, has been working to build a patent pool containing a number of patents that are essential to the 802.11 family of standards. In April 2005, Via Licensing announced that availability of a joint license to the essential patents held by France Telecom, Fujitsu, Japan Radio Company, LG Electronics, Philips Electronics, and Sony.[117] The royalties for this license begin at $0.55 per licensed product for the first 500,000 units and step down steadily to $0.20 per unit for 10 million to 20 million units and $0.05 per unit for units above 40 million per year.[118] But of course that license does not extend to all the patents that cover the technology.

3. Other Examples.—These examples, while extreme, are by no means atypical of the multicomponent nature of products, particularly in the information technology industries. To cite just three other examples, seven different companies hold 177 patents covering recordable DVD media,[119] and another five firms outside the pool hold another 110 patents.[120] And of course there may be others. Second, the ownership of the MP3 music format has been claimed by multiple parties, and even those who paid royalties to the party who seemed to be the legitimate inventor have been sued by others. Most notably, Microsoft was ordered to pay $1.52 billion for infringing on an

113. U.S. Patent No. 5,949,793 (filed Sept. 7, 1999), *available at* http://www.speedus.com/patents/ (follow "View Patent Documentation" hyperlink).

114. Speedus Corp., Speedus - Initiatives & Products (2006), http://www.speedus.com/business_activity.php.

115. Ed Sutherland, WiMax, 802.11n Renew Patent Dcbate (Apr. 7, 2005), http://www.wi-fiplanet.com/columns/article.php/3495951.

116. Symbol Techs., Inc. v. Proxim, Inc., No. Civ. 01-801-SLR, 2004 WL 1770290, at *1 (D. Del. July 28, 2004).

117. Via Licensing Corp., Via Licensing Announces Availability of Joint Patent License for IEEE 802.11 Standard (Apr. 14, 2005), http://www.vialicensing.com/news/details.cfm?VIANEWS_ID=294.

118. Via Licensing Corp., IEEE 802.11 Licensing Fees, http://www.vialicensing.com/licensing/IEEE80211_fees.cfm (showing the standard licensing fees for different units per year).

119. DVD 6C Patent Pool, http://www.dvd6cla.com (last modified Mar. 14, 2007).

120. Layne-Farrar & Lerner, *supra* note 51, at 32 tbl.1.

MP3 patent even though it had already licensed the technology from other patent owners.[121] Finally, there may be as many as 4,000 patents covering aspects of radio-frequency identification devices (RFID chips).[122] In both cases there are efforts to build patent pools to aggregate the rights to produce these devices, as there has been in the Wi-Fi case, though the RFID pool in particular has rights to only a small subset of the necessary patents. And because there is no requirement that a patent owner participate in such an organization, there is no way to guarantee that a pool will actually find and include all or even most of the patents covering a new technology. For example, Layne-Farrar and Lerner survey nine different patent pools, most arising out of standard-setting efforts. They find that the pools have licenses to anywhere between 5% and 89% of the relevant patents specifically identified to cover the standard, and that firm participation rates range from 1% to 58%.[123] Pools can help, then, but they clearly cannot alone aggregate all the rights necessary in a stacked industry.

The problem is even worse than these examples suggest. Each of the case studies we have identified in this Article involve technologies that are not themselves sold as products to customers. Rather, the technology at issue is itself but one component of a larger product. People do not buy Wi-Fi capability or RFID chips; they buy computers or products with those features embedded in them. The true measure of the stacking problem must take all of these patents and add in all the other patents covering other components of the end product. As an example, Bruce Perens suggests that using the World Wide Web implicates thirty different standards, each of which might potentially have its own set of patents to consider.[124] This "metastacking problem"—the need to integrate a number of different standards, each of which has multiple patents—significantly exacerbates the royalty stacking issues we have discussed.

B. Empirical Analysis of Court-Ordered Royalties

Our second empirical study is an analysis of all the court decisions setting reasonable-royalty rates. Our goal here is to determine the extent to which rates differ by industry or are dependent on whether the invention is part of a multicomponent product. We use these data to get at least some

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121. *See, e.g.*, Douglas Heingartner, *Patent Fights Are a Legacy of MP3's Tangled Origins*, N.Y. TIMES, Mar. 5, 2007, at C3. This case also illustrates the problem of determining a reasonable royalty rate for one component (certain MP3 patents that are used in the Windows Media Player) of a complex product (the Windows operating system).

122. *See* Barnaby J. Feder, *Consortium to Pool Radio-Tag Patents*, N.Y. TIMES, Aug. 10, 2005, at C3 (claiming that more than 3,000 RFID patents are in existence); Doug Lichtman, Defensive Suspension in Standard-Setting Organizations 8 (Nov. 15, 2005) (unpublished manuscript), *available at* http://www.law.uchicago.edu/files/lichtman/def-susp.pdf.

123. Layne-Farrar & Lerner, *supra* note 51, at 32 tbl.1.

124. Bruce Perens, *The Problem of Software Patents in Standards*, *in* 3 THE STANDARDS EDGE: OPEN SEASON 173, 174 (Sherrie Bolin ed., 2005).

sense of the extent to which the reasonable-royalty rules in patent cases succeed in solving the component patenting problem by reducing the royalty rate granted to account for the contribution of other components of the product. We try to get at this question in two ways: directly, by classifying certain patents as covering a component rather than an entire system, and indirectly, by classifying patents by area of technology and noting that certain industries are much more likely to have component-based products than others.

We collected all the cases reported in Westlaw from 1982 through mid-2005 that actually awarded reasonable royalties to patentees.[125] The result is a surprisingly small number of cases—only fifty-eight. There are several reasons for this. First, while patent litigation has been growing in significance, relatively few patent cases go to trial every year—only about 100.[126] About 80% of patent cases settle,[127] and another 10–15% are resolved without trial, usually by finding noninfringement or invalidity.[128] Those settlements and pretrial rejections of the patentee's claim are not included in our data set. Second, in many of the cases that do go to trial, the patentee loses, either because the patent is held invalid,[129] unenforceable, or not infringed.[130] Third, many of the cases that the patentee wins are settled without a damages award, particularly if (as commonly happens) the judge bifurcates the damages trial from the liability trial. Fourth, in those cases that do result in a damages award, the damages award is frequently based on lost profits rather than a reasonable royalty and therefore is excluded from our data set. Indeed, lost-profits cases are overrepresented in the subset of cases that actually go to trial, because those cases involve a patent owner seeking to exclude a competitor from the market, a type of case that is significantly less likely to settle than cases in which a patentee seeks only a royalty. Significantly, in order to avoid bias we also exclude from our data set decisions that do not make it clear whether the basis for decision was lost profits or reasonable royalty. This further reduces the number of cases.

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125. A description of the case research methodology is attached as Appendix B.

126. Moore, *supra* note 71, at 374.

127. Kesan & Ball, *supra* note 32, at 259. Kesan and Ball find approximately ninety cases a year that reflect judgments of infringement. *Id.* at 275. Many of those are preliminary rulings, however, with validity or enforceability still to be considered. Only between thirty and fifty cases a year resulted in damage awards. *Id.* at 278.

128. *Id.* at 271; William M. Landes, *An Empirical Analysis of Intellectual Property Litigation: Some Preliminary Results*, 41 HOUS. L. REV. 749, 761 (2004) (noting that 5.38% of patent cases go to trial).

129. Forty-six percent of all patents litigated to judgment are held invalid. Allison & Lemley, *supra* note 71, at 205. At trial, the numbers are somewhat smaller but still significant. *Id.* at 212.

130. For cases that go to trial, Kimberly Moore finds that 33% of those where validity is at issue are held invalid, 27% of those where enforceability is an issue are held unenforceable, and 35% of those where infringement is at issue are held not infringed. Moore, *supra* note 71, at 390. Moore's numbers differ from Allison and Lemley's because Allison and Lemley tested all reported dispositions, including summary judgments and judgments as a matter of law, while Moore tested only trials, both reported and unreported. Allison & Lemley, *supra* note 71, at 194–97; Moore, *supra* note 71, at 380.

Finally, we do not have any way of evaluating pure verdicts. Instead, our data set is limited to the subset of cases in which a court has written an opinion disclosing the royalty awarded, either as part of a verdict in a bench trial, a judgment as a matter of law after a jury trial, or an appeals court decision reviewing a damages verdict. This last fact in particular creates an unavoidable bias away from jury verdicts and toward court opinions,[131] as well as causing cases that survive to appeal to be overrepresented in our database. It also results in some written decisions from which it is impossible to determine the royalty percentage, either because it is not mentioned or because it is awarded in dollars per unit and it is impossible to determine the price of the unit.[132] We exclude those cases as well, reducing the number of cases we can evaluate from fifty-eight to forty-seven.

131. Indeed, only eight of the sixty opinions in our data set involve jury verdicts, a rate far lower than the percentage of all cases ultimately decided by a jury. Among those jury verdicts, the average royalty rate was 13.7%, which is virtually indistinguishable from the total average royalty rate across all cases. This provides at least some evidence that the skew away from jury awards may not significantly affect the findings in this Article.

132. Where it is possible to calculate a royalty rate based on the contemporary sales price of the unit, we have done so and noted that fact in Appendix B.

The results are presented in Table 1.

Table 1: Reasonable-Royalty Rates in Trial Verdicts

					Confidence Intervals for Mean					
	N	Mean	Median	Standard Dev.	90%		95%		99%	
All Cases	47	13.13	10.00	I0.63	10.59	I5.68	10.09	16.I7	9.15	I7.I2
Product Category	29	14.71	10.00	12.17	11.00	18.41	10.28	19.14	8.90	20.52
Process Category	7	11.57	11.20	5.05	8.44	14.70	7.83	15.32	6.66	16.48
Component Category	11	9.98	10.00	8.32	5.86	14.09	5.06	14.90	3.53	16.43
Mechanics Group[133]	29	15.55	15.00	11.39	12.08	19.01	11.40	19.69	10.11	20.98
Electronics/IT Group	8	6.49	6.47	4.65	3.79	9.19	3.27	9.72	2.26	10.72
Chem./bio Group	15	11.30	8.00	9.09	7.45	15.15	6.70	15.90	5.27	17.33
Acoustie	1	15.00	15.00							
Automotive	3	17.50	20.00							
Biotechnology	2	9.60	9.60							
Chemistry	13	11.98	8.00							
Communications	1	5.94	5.94							
Computer-Related	2	5.50	5.50							
Electronics	2	7.50	7.50							
Energy	0									
Mechanieal	17	16.55	10.00							
Medical Devices	7	11.36	10.00							
Optics	2	10.00	10.00							
Pharmaceuticals	0									
Semiconductors	2	8.25	8.25							
Software	1	I.00	1.00							

The average royalty rate granted in all reasonable-royalty cases is 13.13% of the price of the infringing product. This number will strike many patent lawyers as surprisingly high; very few patent licenses negotiated without litigation (or even in settlement of it) result in royalty rates anywhere

133. The numbers in this section add to more than the total *N* of 47 because a few inventions fit into more than one category.

near that high.[134] There are some structural reasons why litigated royalty rates would be higher than negotiated ones. The courts presume that the patent is valid and infringed in setting the reasonable royalty; negotiators in the real world do not. We think this disparity is an empirical verification of the probabilistic nature of patent rights we have discussed elsewhere.[135] And the subset of cases that make it all the way to verdict presumably excludes cases in which very little money is at stake, since the litigation costs generally make going to trial on such cases uneconomical. This may skew the royalty rates in the cases that do make it to court upwards. Nonetheless, we do not think these factors can fully explain the high royalty rates we find. The disparity in royalty rates also reflects the economic phenomena we discussed earlier.[136]

To get at the question of whether courts successfully discount royalty rates in component cases, we evaluated each patent to see whether the invention was directed to an entire product sold separately or to a single component of a larger integrated product. This exercise required substantial judgment. Relatively few patent claims expressly identify themselves as covering only a component of a larger product. Some are silent on the issue. Others are drafted as patents covering an entire system, but the point of novelty is limited to a particular component in an otherwise old system. We have classed these claims as component inventions to avoid the artificial distinctions that would otherwise be drawn based on the way a claim is drafted.[137] And we have included as components only those products whose royalty base was calculated as a part of the larger product, excluding those

134. Unfortunately, licenses are generally confidential, and there is no reliable source for average royalty rates. *See supra* notes 81–83 and accompanying text. One estimate from the *Licensing Economics Review* found an average royalty rate of 6.7%, less than half the litigation rate. *Industry Royalty Rate Data Summary*, LICENSING ECON. REV., Dec. 2005, at 6, 7. Because those data were based on calculations from publicly available license agreements, their average is likely significantly higher than the actual royalty average, for reasons we have explained.

135. Lemley & Shapiro, *supra* note 25, at 95.

136. It also demonstrates that the circularity we identified above is not complete, just as our model predicts.

137. This issue has proven controversial in patent reform. In the fall of 2005, two competing drafts of a bill designed to deal with the problem of component inventions were circulated. H.R. 2795 addressed the problem by requiring courts to determine the value of the "inventive contribution" of the product. H.R. 2795, 109th Cong. § 6(1)(B) (2005). An alternative print offered by the life sciences industries made a seemingly small change, from "inventive contribution" to "contributions arising from the claimed invention." Coalition for 21st Century Patent Law Reform, Coalition Draft Mark-up of Amendment in the Nature of a Substitute to H.R. 2795 (Sept. 1, 2005), http://www.fr.com/news/2005-09-14_Coalition_Draft.pdf. Unfortunately, this change could have the consequence of allowing patentees to manipulate their damages by changing the way they claim their invention. For example, the inventor of the intermittent windshield wiper could claim the wiper alone, or alternatively could choose to claim a car including an intermittent windshield wiper. The invention is the same, and the patentee shouldn't be able to capture more money by phrasing the claim in the second way rather than the first. But the pharmaceutical draft may produce just such an effect, since the "claimed invention" is literally the whole car and not just the windshield wiper. To avoid this formalism, we have evaluated each claim in order to identify the inventive component.

that were sold separately, since many of the royalty problems we discuss in this Article should not come up if the product is sold separately.

As Table 1 indicates, fact finders do in fact grant somewhat lower royalty rates for component inventions. The royalty rate for components is approximately 10.0%, compared with 13.1% for all inventions and 14.7% for integrated product claims. But the difference is fairly modest. To see just how modest, consider that the reduction in royalty rate for component inventions is equivalent to a conclusion that there are on average less than 1.5 components in a multicomponent invention. Obviously, this does not reflect commercial reality, at least in the telecommunications and computer industries. Even if each of the litigated component inventions was part of a simple two-component product, we should expect to see a more significant reduction in the royalty rate if the system were working as intended.[138] And since we know that in many of the component cases, many different inventive contributions to the product are included in the royalty base, it is reasonable to conclude that the legal doctrines designed to make the reasonable royalty track the actual value of the patented contribution are not working, at least not fully.

We also divided our data set by industry category, on the theory that this might provide another way to analyze the problem. If, as is commonly believed, component inventions are ubiquitous in the electronics and information technology industries but relatively uncommon in chemistry and the life sciences, royalty rates should be significantly greater in the latter industries if the damages system were equilibrating well.

We first categorized the royalty awards into the fourteen industry categories created by Allison and Lemley.[139] Those categories are more useful than industry divisions based on the PTO classification system, since Allison and Lemley have shown that that classification system contains significant errors. Unfortunately, the small number of cases in our study makes it impossible to draw any statistically significant conclusions once we have divided the patents this finely. As an alternative, we also categorized the royalty decisions into the broad groups of mechanical, chemical, and electrical inventions. We do find statistically significant differences in the royalty rates granted in those groups. Electronics (including information technology) inventions have the lowest average royalty rate (6.5%), less than half of the overall average. Interestingly, chemical and biotechnological inventions are also below the mean, with an average royalty rate of only 11.3%. It is mechanical inventions that are awarded the highest royalty rate,

138. While it is conceivable that this modest reduction reflects a considered conclusion that the patented component is the most significant contributor to patent value in each case, overwhelming the contribution of all other components, we are skeptical that this is in fact true. That result seems particularly implausible given that in many cases several different components of the same product are patented.

139. John R. Allison & Mark A. Lemley, *Who's Patenting What? An Empirical Exploration of Patent Prosecution*, 53 VAND. L. REV. 2099, 2110–12 (2000).

15.6% on average. While we urge some caution in interpreting these data—the large-scale groups concatenate a number of very different industries—they do suggest that the industries in which multicomponent products are most common also have the lowest average royalty rate. As with the direct analysis of component technologies, the differences are somewhat modest, here representing an average of only two components in any given product.

The litigation data, then, suggest that the reasonable-royalty rules do in fact accommodate component products but only to a limited extent. Based on these data, which are admittedly far from perfect, it seems highly unlikely that this accommodation fully solves the problems we identified earlier both theoretically and empirically. In particular, the high absolute royalty rates and the modest differences between component and noncomponent inventions suggest that problems associated with holdup and royalty stacking have not been completely solved by existing legal rules. Indeed, to put some perspective on this issue, consider that the average profit margin across all industries for the past twenty-five years is 8.3%.[140] Even the "low" royalty rates on components or in the electronics industries are sufficiently high that paying royalties for one patent can sometimes wipe out essentially all the expected profit from the product.[141]

VI. Policy Recommendations

A. Limiting Injunctions and Imposing Stays

We have emphasized the holdup power that patent owners wield because of the threat that they will obtain injunctions. While we strongly believe that the threat of holdup gives excessive reward to patent holders, especially in component industries, we consider the presumptive right to injunctive relief to be an important part of the patent law. In most cases, there will be no question as to the patentee's entitlement to an injunction.

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140. Vitaliy Katsenelson, *The Profit Margin Paradigm*, THE MOTLEY FOOL, Mar. 1, 2006, http://www.fool.com/investing/value/2006/03/01/the-profit-margin-paradigm.aspx.

141. While profit margins vary by industry, there is no reason to believe they are systematically higher in the IT or other component industries. Take this example from 2002:

> Electronics/electrical equipment. GE, the industry's revenue leader, also was among the best in profit margin with 11.3%. The industry's next revenue leader, Siemens AG, No. 13 in the IW 1000, had a profit margin of 2.4%. Hitachi Ltd., No. 16, had 1.2%. The industry's best profit margin was posted by United Microelectronics Corp. of Taiwan. The company, No. 551 in the IW 1000, showed a profit margin of 44.7% on revenues of $3.2 billion. United Microelectronics is a leading contract manufacturer of semiconductors, and has alliances and joint ventures with such other IW 1000 stalwarts as IBM Corp. and Infineon Technologies AG.

Richard Osborne, *Industrial Strength*, INDUS. WK., June 2002, at 38, 42. One should not take this too far. For starters, these numbers report some measure of accounting profits, not economic profits. In addition, other subsets of the IT industry, notably software, may have substantially higher accounting profit margins. And accounting profits on individual products are not the same as overall corporate profits, but of course corporate profits are simply the aggregate of profits on individual products less general expenses.

To begin, we stress that our analysis in this Article is expressly limited to situations in which the patent holder's predominant commercial interest in bringing a patent infringement case is to obtain licensing revenues. Our policy recommendations here pertain only to this type of situation, where the patent holder can claim reasonable royalties but not lost profits, and not to settings in which the patent holder suffers significant lost profits as a result of the allegedly infringing activities of the downstream firm and seeks to use the patent to exclude a competitor from the market in order to preserve its profit margins. In cases involving significant lost profits, we favor a presumption that the patent holder will be granted a permanent injunction, perhaps with a stay to allow the infringing firm to redesign its product. The presumptive right to a permanent injunction in these cases is justified in part for reasons of equity and in part because of the grave difficulties associated with calculating and awarding lost profits on an ongoing basis. Similarly, a patentee who assigns or exclusively licenses its patent to someone who competes significantly against the infringing firm also should ordinarily be entitled to an injunction. Even if none of these conditions hold, some injunctions will not lead to a risk of holdup, and so even patentees who do not meet any of the criteria listed above will often be entitled to an injunction, perhaps after a stay to allow the infringing firm to redesign its product. This is the virtue of equitable discretion: courts can grant injunctions when they are warranted, without being bound to grant them when they create more problems than they solve.

Historically, the Federal Circuit effectively mandated injunctions for patent infringement, without consideration of whether the patentee needed an injunction or the hardship that an injunction against a base product might impose on a defendant. But the Supreme Court has recently held in *eBay Inc. v. MercExchange, L.L.C.* that district courts have the power to deny injunctions in appropriate cases,[142] and a number of district courts have responded by denying injunctions to nonmanufacturing patent owners.[143] We think that one circumstance in which courts should consider denying an injunction—or at a minimum delaying it—is when the product that would be enjoined contains multiple components, of which only one is the subject of the patent suit.[144]

An additional prerequisite for denying an injunction should be that the defendant developed the technology independently rather than copying it

142. eBay Inc. v. MercExchange, L.L.C., 126 S. Ct. 1837, 1841 (2006).

143. *See, e.g.*, Paice LLC v. Toyota Motor Corp., No. 2:04-CV-211-DF, 2006 WL 2385139, at *4 (E.D. Tex. Aug. 16, 2006) (applying the traditional four-factor test for equitable relief and holding that an injunction should not be granted); z4 Techs., Inc. v. Microsoft Corp., 434 F. Supp. 2d 437, 444 (E.D. Tex. 2006) (denying an injunction after applying the four-part test).

144. The *z4* court expressly considered this factor in denying injunctive relief. *z4*, 424 F. Supp. 2d at 441.

from the plaintiff.[145] While the goal of patent remedies should be to align the plaintiff's recovery with the actual value of its technical contribution, there is some risk that limiting damages and injunctions could encourage unscrupulous companies to steal another's technology, reasoning that if they are caught they will only have to pay ex post what they would have had to pay ex ante for a license (adjusted to reflect the finding of validity and infringement, plus considerable litigation costs).[146] Under current law, the willfulness doctrine serves to deter such conduct, but it has sufficient problems that patent reformers may well modify or even eliminate it.[147] Most notably, an infringement can be deemed willful under current law even if the defendant developed its product independently and without knowledge of the plaintiff's patent.[148]

Our preferred solution to holdup in cases where the patent holder's claims are based on reasonable royalties is for the courts to apply the following procedure.

First, the court should evaluate the cost that the infringing firm would have to incur to redesign its product to avoid infringing the patent.[149] If this cost is high relative to the value that the patented technology has added to the infringing firm's product, no permanent injunction should be issued.[150] In this situation, empowering the patent holder to obtain an injunction is likely to lead to royalties well in excess of the inherent value of the patented technology—an outcome that is neither fair nor efficient. In this ease, if the parties cannot reach an agreement on the royalty rate, the court should calculate the reasonable-royalty rate and ensure that the infringing firm pays these royalties to the patent holder. In virtually all cases, the reasonable-royalty rate would need to be determined in any event to calculate the damages owed by the infringing firm to the patent holder, so this would not

145. We acknowledge that this will sometimes create problems of proof. But in most of the cases of interest in our model the accused infringer was not even aware of the patent or the patentee when it adopted its technology, so copying will not be an issue. In other cases, notably those involving FDA approval, copying will likely be admitted.

146. *See* Fromson v. Western Litho Plate & Supply Co., 853 F.2d 1568, 1574–76 (Fed. Cir. 1988) (stating this objection in detail, but seeming to draw from it the conclusion that reasonable royalty rates should themselves be enhanced); Panduit Corp. v. Stahlin Bros. Fibre Works, 575 F.2d 1152, 1158–59 (6th Cir. 1978) (drawing the same conclusion).

147. *See, e.g.*, Patent Act of 2005, H.R. 2795, 109th Cong. § 6 (2005) (proposing to impose significant limits on the use of the doctrine); Lemley & Tangri, *supra* note 27 (discussing these problems and proposing limits on the willfulness doctrine short of abolition).

148. *See* Lemley & Tangri, *supra* note 27, at 1089–94 (describing situations in which courts will apply a presumption of willful infringement).

149. For the purpose of evaluating both the cost and the time necessary for redesign, the court may be able to rely usefully on statements made by the parties regarding the level of royalties that would be reasonable, especially if the plaintiff has argued that design-around is difficult or time consuming or the defendant has argued the opposite.

150. As always, the value of the patented technology should be measured in comparison with the next best alternative, as of the time that the product was initially designed. The ratio of redesign costs to the value of the patented technology is the variable *C* in our analysis.

impose any extra burden on the court or the parties.[151] Alternatively, if the redesign cost is not large relative to the value that the patented technology adds to the infringing firm's product, the court should issue a permanent injunction, primarily to force the parties to voluntarily negotiate a licensing arrangement rather than rely on the court to determine the reasonable royalties that will apply to future sales by the infringing firm.

However, even if the redesign costs are not large, the court should evaluate the time lag needed for the infringing party to redesign its product to avoid infringing a patent on one component of that product. If the infringing firm claims that it can design around the patent, the court should issue a stay of its permanent injunction that is long enough to permit the infringing firm to complete the redesign, if there is one, in an efficient and timely manner. The infringing party would, of course, be required to pay reasonable royalties to the patent holder for any sales made during the period of the stay. With such stays, holdup based on the disparity between the relatively large value of the patented product and the relatively small value associated with the patented feature is sharply reduced or eliminated.[152] Holdup based on the need for the downstream firm to redesign its product early, and thus incur the redesign costs even if the patent would be proven invalid, is also eliminated. The net result is that the gap between the negotiated royalty rate and the benchmark level reflecting the true value contributed by the patent holder is reduced. This is efficient and favorable for consumers, and still gives the patent holder a return at least as large as is warranted based on the patent holder's actual contributions to the product.

We recognize that issuing such stays will reduce the incentives of patent defendants to redesign their products while patent litigation is pending. We consider this a plus. Such redesign costs will prove entirely wasteful if the patent is later proven invalid, so avoiding them is socially desirable, especially in cases involving weak patents, where the likelihood is high that these redesign costs will indeed be wasted. It is true that stays will allow the infringing party to keep infringing for some period of time after the patent is found valid and infringed, but we do not see this as terribly unfair to the patent holder, since the infringing party will owe reasonable royalties for those infringing sales. Thus, any adverse impact on the patent holder is no greater than the impact caused by the infringement during the pendency of litigation.

As we emphasized above, a patentee's ability to obtain an injunction against an entire product on the basis of infringement of a single component

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151. One of the virtues of this approach is that the level of reasonable royalties can be set based on historical information and does not need to be adjusted as market conditions change, just as patent licenses commonly specify a royalty rate that does not change based on evolving market conditions. Only in exceptional circumstances would it be possible to accurately award future lost profits without some mechanism for evaluating market conditions as they change over time.

152. Shapiro explores this impact of stays in the formal model in Shapiro, *supra* note 7, at 18–21.

in that product tends to drive negotiated royalty rates higher than would be warranted by the inventive contribution of the patent. As long as that holdup problem remains, changing the damages calculation rules will be at best only a partial solution to the royalty stacking problem. Limiting patentees in component industries to recovery based on the value of their contribution will require not just damages reform, but vesting in the courts at least some power to deny or limit injunctive relief in component cases.

B. Design-Around Alternatives

The danger that reasonable royalties will be set too high in component cases will be sharply reduced if the courts base their estimates of reasonable royalties on an assessment of the value of the patented component *in comparison with the next best, noninfringing alternative way to create that component.* After all, even if the component in question is valued highly by consumers, the patent holder's contribution may still be very modest if there are other noninfringing ways to make a noninfringing version of the product that are equally good or nearly as good. The benchmark rate for reasonable royalties depends predominantly on the value of the patented component compared with the next best alternative.[153] In our analysis above, the price and margin earned on the product as a whole were irrelevant to valuing the patented feature.[154]

In lost profits cases, patent damages have long been constrained by the availability of noninfringing alternatives.[155] Surprisingly, however, the use of noninfringing design-arounds to set royalty rates is less clearly established in the reasonable-royalty context.[156] But the existence of such a noninfringing alternative should absolutely constrain a reasonable royalty for a patented component, just as it does in a lost profits award. Indeed, if the courts do not permit the use of design-arounds in reasonable-royalty cases, they risk

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153. Of course, the next best alternative may be patented too. The proper comparison is between the cost and value of the patentee's component and the cost and value of the alternative, including patent royalties that would have to be paid on the alternative where appropriate.

154. In theory, the price and margin earned on the product as a whole could be relevant in valuing the patented feature, but only to the extent that the patented feature (compared with the best noninfringing alternative) adds to the unit sales of the product as a whole. This is presumably a second-order effect for all minor components of a complex product, and even for major components if there exists a nearly equivalent noninfringing way of making that component.

155. *See* Grain Processing Corp. v. Am. Maize Prods. Co., 185 F.3d 1341, 1356 (Fed. Cir. 1999) (holding that proof of noninfringing substitutes that were not on the market during the infringement can still limit lost profit damages).

156. One case that seems to permit such a use is *Riles v. Shell Exploration & Production Co.*, 298 F.3d 1302 (Fed. Cir. 2002). The court there held:

> Shell also urges that a reasonable royalty may not exceed the cost savings between its proposed non-infringing alternative installation . . . and the patented method. . . . Upon remand, the district court is free to entertain additional evidence by the parties on this fact issue in its re-determination of the damage award. The trial court may also consider any other evidence about non-infringing alternatives.

Id. at 1313.

creating the anomalous result that the reasonable-royalty "floor" is higher than the actual lost profits from infringement.[157] We strongly encourage the courts to consider the noninfringing design-around alternatives available when the product was initially designed when valuing patented features or components for the purpose of establishing reasonable royalties. In particular, the Federal Circuit should make it clear that a significant factor influencing the royalty rate a plaintiff could charge is the presence or absence of noninfringing alternatives.

C. Consideration of Unpatented Components

A second key step in solving the royalty stacking problem in patent damages is to ensure that the fact finder has the information necessary to assess the contribution of a component invention in the context of the value of the entire product claimed in the royalty base. In theory, *Georgia-Pacific* permits this assessment now in its factor thirteen, though it does not expressly require it.[158] Congress is considering amending the patent damages statute to expressly require courts faced with component inventions to consider the importance of other components of the product sold that are not covered by the patent at issue.[159] We support such an amendment because it will emphasize to judges and juries that the royalty rate must be based not just on the value of the invention in the abstract, but what it contributes in the context of the other elements of the accused product. Even if it does not pass, courts have and should exercise the power to consider those components under existing law.

A focus on the inventive contribution of the patent in relation to other contributions to the value of the overall product will also prevent patentees from manipulating the inquiry by claiming what is really a component invention as a broader system. If the inventive contribution is an intermittent windshield wiper, the royalties awarded should not depend on whether the inventor claims the wiper itself or a car including a wiper. Under current practice, those two patent claims may well generate different royalties. That makes no sense.

Cementing in the law the obligation to consider other parts of a multicomponent invention is only the first step, however. Courts must also

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157. It is true there is no rule that reasonable royalties cannot exceed provable lost profits. *See* Monsanto Co. v. Ralph, 382 F.3d 1374, 1384 (Fed. Cir. 2004) (upholding a jury's determination of reasonable royalties that were in excess of any anticipated profits). However, we think it extremely unlikely that a royalty that exceeds the amount of money the patentee could have made by excluding the defendant entirely is reasonable.

158. *See also* Paymaster Techs., Inc. v. United States, 61 Fed. Cl. 593, 613 (2004) ("When considering the reasonable royalty of the accused device, the stacked royalty of other patents involved . . . must also be considered.").

159. *Amendment in the Nature of a Substitute to H.R. 2795, the "Patent Act of 2005": Hearing Before the Subcomm. on Courts, the Internet, and Intellectual Property of the H. Comm. on the Judiciary*, 109th Cong. (2005).

figure out ways to consider the value of those other contributions without unduly disrupting the trial, or else it will remain a "meaningless inquiry."[160] As an initial matter, we think that defendants in such cases should be entitled to introduce evidence about prior judgments or licenses covering other attributes of the same product. If a product has a profit margin of 10%, a jury deciding the royalty rate to award on one component of that product is entitled to know that another court has already required the same defendant to pay 6% of the sales price (that is, 60% of the profits) to license another component of the product. Similarly, if the defendant has taken royalty-bearing licenses to other components without litigation, it should be entitled to introduce that evidence as well.

But prior judgments involving the same product will show up only rarely, since most cases settle.[161] Even prior licensing deals outside of litigation won't provide a complete picture of the total economic costs a defendant faces or the actual contribution of the patented invention. First, and most obviously, it will work perfectly only for the *last* patent to be asserted against a product. The first time someone asserts a patent against a particular product, there will be no such prior record. Second, licensing deals often involve terms other than pure royalty payments. They may require a lump-sum payment instead of or in addition to a royalty rate. They may involve a business transaction in which products change hands, or even mergers or acquisitions. And many patent licenses involve multiple patents licensed for different products, often running in both directions (a "cross license"). All of these licenses involve economic costs to the licensee, but they will not all be transparent to a jury. Finally, admitting evidence of payments to outside parties works only for the components of the base product that are actually acquired from outside and does not account for the large portion of the technology that is likely to have been contributed by the defendant itself.

An alternative to a focus on the costs of noncovered components is to focus on the value of those components to buyers. This is clearly correct in principle; the benchmark we advocate above was determined entirely by the value to buyers of the patented component and did not depend at all upon the value contributed by other components or by the firm selling the infringing product.[162] Focusing on the value of the patented component or feature is

160. BLAIR & COTTER, *supra* note 14, at 215.

161. *See* Landes, *supra* note 128, at 769.

162. For simplicity, we assumed above that the value contributed by one patented component was independent of the other patented components. When the various patented components are complementary in creating value, the sum of their incremental contributions will exceed their total contribution. In this setting, with multiple patented components, if the royalty rate on each component were set at its incremental value (given the presence of the other patented components, and measured in comparison with the next best alternative for the component in question), the sum of the royalty rates would exceed the combined value of the various patented components. This is one reason why in a royalty stacking situation it may be important when determining the reasonable royalty rate for one patent to also consider the value created by other patented technologies incorporated in the same product and their reasonable royalties as well.

consistent with the goal of *Georgia-Pacific* and with the entire market value rule, which allows patentees to capture royalties on a full product only where the patented component is the driving force behind the larger product. But actually implementing that rule requires courts to employ metrics for determining the share of value attributable to the patent. At a minimum, courts should consider technical expert testimony on the contribution the patented component makes to the product. But we think courts should go further, permitting survey evidence of customers about the reason they purchase the product and the attributes of that product they find useful.[163] Courts have significant experience with evaluating such survey evidence in the trademark context and have done a good job of weeding out biased or misleading surveys.[164] They can also admit economic expert testimony on what economists call feature hedonic regression, which relies on variety in component composition and product pricing to estimate the contribution of particular features.

D. Facilitating Private Aggregation of Royalty Rates

While it is possible to change legal rules in ways that reduce the royalty stacking problem in court, doing so only indirectly addresses the vast majority of royalty stacking problems that come up outside the trial context.[165] One way to address those issues is to permit or even facilitate private aggregation of royalty rates for component products. Parties negotiating royalty rates for a patent covering a component of a product rationally ought to take into account the value of the patented contribution, the value of other contributions (both from within the company and from other patent owners), and the cost of manufacturing the product. The resulting royalty agreement might be complex. Perhaps the producer could set a total cap on the rates patent licensors could charge, with the result that the royalty rate paid to each one would actually decline as other patent owners asserted rights in the product, reducing the relative contribution of each patentee. Or if that were implausible, producers might negotiate a "step-down" royalty, paying each new claimant a declining percentage to reflect the claims already made against the product.[166]

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163. At least one court has admitted such evidence. *See* Applera Corp. v. MJ Research, Inc., No. 3:98CV1201(JBA), 2004 WL 914253, at *1 (D. Conn. Mar. 11, 2004). For a discussion of how such surveys might work, see Eugene P. Ericksen & Sarah M. Butler, *The Use of Surveys in Intellectual Property Disputes*, *in* ECONOMIC APPROACHES TO INTELLECTUAL PROPERTY 125, 136–39 (Gregory K. Leonard & Lauren J. Stiroh eds., 2005).

164. On the sophistication and use of surveys in trademark law, see 5 J. THOMAS MCCARTHY, TRADEMARKS AND UNFAIR COMPETITION §§ 32:158–:196 (4th ed. 2006).

165. That is not to say damages reform would have no effect on cases not litigated to judgment. As we discussed *supra* Part II, the royalties set in private licensing negotiations are driven in significant part by the results a patentee could obtain by going to trial. So changing those remedies will affect negotiated royalty rates.

166. For a brief discussion of how such a step-down system might work, as well as other alternatives, see Lemley, *supra* note 45, at 160–67.

Individual companies are free to negotiate something of this sort today. But they rarely do. One problem is that private solutions only affect those who choose to participate in the private ordering scheme, and patent owners have incentives not to do so. In some cases, cross licenses and patent pools will help, but the private solutions are unlikely to be very valuable in dealing with patent owners who are not producers. This reflects the underlying tensions and externalities associated with the problem of Cournot complements. And since as we have seen the law gives patent holders a shot at a share of profits from the product out of proportion to their contribution, there is no reason they would agree to such an arrangement under the current law. But if we solve that problem—if we align patent remedies with the contribution of the patented invention, rather than permitting patentees to capture more—the bargaining threat points will at least shift in a direction that reduces the Cournot-complements problem that inherently arises in the presence of multiple patents.

Patents that cover industry standards pose an even more difficult problem. When competitors in an industry get together to discuss the products they will produce, for example in an SSO, antitrust concerns naturally arise.[167] Those concerns are only heightened when participants in the organization must discuss the price of a patent license. Indeed, many SSOs refuse even to permit discussions of royalty rates for fear of antitrust concerns, relying instead on a vague promise to license under "reasonable and nondiscriminatory" terms.[168] And no SSO we are aware of has tried to implement a royalty cap or a step-down royalty system, which both raise even more antitrust flags since they involve not only a discussion of but also an agreement on price.

Obviously, SSOs cannot make an informed decision as to the costs and benefits of a patented technology if they do not know how much it costs to implement. And unless everyone who owns a patent covering a particular technology is a participant in the SSO, even disclosures of license prices by SSO members will not suffice to give a true picture of the cost of licensing all the rights needed for that technology. Antitrust law should permit SSOs at a minimum to determine what participants own patents covering a standard and what licensing terms they are offering for those patents. And in some circumstances, antitrust law should go further, permitting groups to collectively negotiate royalty rates. Such negotiations are very likely to be procompetitive if the technology would otherwise be so encumbered by

167. For a general discussion of antitrust issues in standard setting, see 2 HERBERT HOVENKAMP ET AL., IP AND ANTITRUST, at 35-1 to -71 (2007); Joseph Farrell et al., *Standard Setting, Patents and Hold-Up*, 75 ANTITRUST L.J. (forthcoming 2007), *available at* http://faculty.haas.berkeley.edu/shapiro/standards2007.pdf; and Mark A. Lemley, *Intellectual Property Rights and Standard-Setting Organizations*, 90 CAL. L. REV. 1889 (2002).

168. Lemley, *supra* note 167, at 1965 & n.320 (citing the example of IEEE).

patent rights and blocking positions that the standard would have difficulty moving forward in the market.

E. Patent Quality and Postgrant Opposition

Our analysis is a reminder of the economic costs associated with improperly issued patents. Improving patent quality will reduce many of the costs identified here that are associated with weak patents, holdup, and the threat of injunctions, simply because it will remove some of the patents that impose those costs. Improved postgrant opposition procedures will help as well, at least to the extent that they prevent weak patents covering commercially important technologies from remaining in force to the point when they can be used to threaten downstream firms with the risk of an injunction. But it is important to recognize that no contemplated patent-quality reform will entirely eliminate the uncertainty associated with patent validity or the problem of royalty stacking, and therefore that improvements in patent quality alone cannot solve the holdup and stacking problems we have identified.

VII. Conclusion

Patents are important to innovation. But in industries that are overly clogged with patents and where patent holdup is a serious danger, they can also impede it. The goal of patent policy should be to ensure that patentees can get paid for their technology but that patent royalties bear some reasonable relationship to what patentees actually contributed. Both our bargaining model and our empirical investigation demonstrate that under current law patentees whose inventions are only one component of a larger product are systematically overcompensated.

The reasonable-royalty floor for patent damages is designed to compensate a patent owner for losses it sustained as a result of infringement, not to punish or deter infringement or even to deprive an efficient infringer of all of the profits from that infringement.[169] But the way reasonable royalties are calculated, particularly for component inventions, has made them into a tool for patentees to capture more than their fair share of a defendant's profit margins. Realigning the reasonable-royalty calculation with its intended purpose—compensation of patent owners—will go a long way toward reducing the incentives of patent plaintiffs to engage in opportunistic holdup.

To be effective, though, damages reform must be coupled with a solution to the holdup problems created by injunctions. Our model suggests that holdup problems in patent cases can be quite significant, but that a relatively simple step—a stay of injunctive relief sufficient to allow the infringer to design around the patent if it can in cases involving reasonable royalties but not lost profits—would significantly reduce that problem as well. The

169. *See* BLAIR & COTTER, *supra* note 14, at 12 (noting this fact, but questioning whether it makes sense).

Supreme Court's recent decision in *eBay Inc. v. MercExchange, L.L.C.* also promises to help solve holdup problems by making permanent injunctions less routine or automatic, but it is too soon to say just what its impact will be. These reforms will help to rebalance the patent system and ensure that it enhances rather than impedes innovation in component industries, including the information technology sector of the economy.

Appendix A: Royalty Stacking with Linear Demand

We explore here the implications of royalty stacking in situations where the constraint on the royalty rate charged by each patent holder arises from the reduction in output that results from higher running royalties. The analysis here complements that in the main text, where the constraint on the royalty rate charged by each patent holder came from the downstream firm's threat to redesign its product or litigate the patent.

In general, the constraint on a patent holder caused by output reduction associated with higher running royalties depends upon the demand curve the downstream firm faces. For simplicity, to illustrate the main economic forces at work, we assume here that the downstream firm faces a linear demand curve: $X = A + V - P$ where X is the output of the downstream firm and P is the downstream firm's price. The parameter A reflects the value of the product if none of the patented features are included. The variable V represents the value added to the product by the patented features at issue, taken as a group. The downstream firm's marginal cost, before accounting for any patent royalties, equals C.

Patentee i owns patent i, which covers a feature that adds value v_i to the product. For simplicity, we make the strong assumption that the patented features are technically independent, so $V = \sum_{i=1}^{N} v_i$, and that the product has already been designed to include all N features.

One benchmark is the first-best outcome ex post. This involves a downstream price that equals marginal cost, C, which implies an output level of:

$$X^F = A + V - C.$$

A second benchmark is the output that would be produced by an integrated firm controlling all N patents. This firm would have some market power, maximizing $(P-C)(A+V-P)$, which implies a price of $P^I = [A+V+C]/2$ and an "integrated firm" output of:

$$X^I = [A+V-C]/2 = X^F/2.$$

Our third benchmark arises if a single firm controls all N patents but is *not* integrated downstream and instead sets a simple, uniform price, i.e., uses linear running royalties. If the single patent holder were to charge a combined royalty rate of R, and if the downstream firm were willing to pay this royalty rather than redesign its product or litigate, then the downstream firm would maximize $(P-C-R)(A+V-P)$, at a downstream price $P(R) = [A+V+C+R]/2$ and a corresponding quantity of $X(R) = A+V-P(R) = [(A+V)-(C+R)]/2$. The patent holder in this circumstance sets R to maximize $RX(R)$, which implies a combined royalty

rate of $R^D = (A+V-C)/2$, resulting in the "double marginalization" output level of:

$$X^D = X(R^D) = (A+V-C)/4 = X^I/2 = X^F/4.$$

We are now ready to consider the royalty-setting game among the patent holders. We model this game as a simultaneous-move royalty-setting game, which is the standard treatment of Cournot complements. Call patentee i's royalty rate r_i, and the aggregate, or "stacked" royalty rate $R \equiv \sum_{i=1}^{N} r_i$. As noted above, if the downstream firm pays an aggregate royalty rate of R rather than litigating, the downstream firm would then set price $P(R) = [A+V+C+R]/2$ and produce $X(R) = A+V-P(R) = [(A+V)-(C+R)]/2$ units of output.

Patentee i sets r_i to maximize $r_i X(R) = r_i[(A+V)-(C+R)]/2$. The first-order condition for r_i is given by $(A+V)-(C+R)-r_i = 0$. For simplicity, we now impose symmetry, so $v_i = v$ for all i and $V = Nv$. In a symmetric equilibrium, $r_i = r$ for all i, and we must have $R = Nr$. Therefore, the first-order condition for r_i becomes $(A+V)-(C+Nr) = r$, which implies that $r = (A+V-C)/(N+1)$, so the combined or "stacked" royalty rate equals $R^S = N(A+V-C)/(N+1)$, with corresponding output level of

$$X^S = \frac{A+V-C}{2(N+1)} = \frac{2}{N+1} X^D.$$

Of course, if there is only one patent, $N = 1$, then there is only one patent holder, and this output level is the same as arises under double marginalization. With more patents, however, output falls, and $X^S < X^D$. For example, with three patent holders, $N = 3$, then $X^S = X^D/2$. In general, the theory of Cournot complements tells us that output falls as the number of patent holders rises, for a given level of V. In this particular model, output approaches 0 as the number of patent holders grows large. Put differently, with a large number of patent holders, the combined royalties will reach the point where the downstream firm's threat to redesign its product comes into play, placing us back in the case considered in the main text. Even in that case, however, some coordination among the patent holders may be needed to avoid an outcome in which the stacked royalty rate is so high that the downstream firm shuts down.

Readers may wonder how royalty stacking can cause such severe problems given that each patent holder, by assumption, contributes valuable technology: each individual patent i adds value v_i to the product, for a combined value of V. The problem is that, in the presence of holdup and opportunism, each patent has the ability to charge a royalty that *exceeds* the value of its patented technology. In terms of the parameters in the model,

there is no reason why the constraint $r_i \leq v_i$ must hold if redesign costs are significant. In fact, in the model used above, each patent holder sets a royalty rate of $r = R^S / N = (A + V - C)/(N+1)$. Substituting $V = Nv$, we get $r = (A + Nv - C)/(N+1)$, which can easily exceed v. Indeed, we will get $r > v$ if and only if $A - C > v$, a relatively weak condition, which only requires that the demand intercept for a noninfringing product less marginal cost, $A - C$, exceed the value of each individual patent holder's contribution. This condition is easily met if there are many patents covering minor features of the product, so v is small.

Appendix B: Case Collection Methodology

- Using Westlaw KeyCite, we searched for all cases citing to *Georgia-Pacific v. U.S. Plywood*, 318 F. Supp. 1116 (S.D.N.Y. 1970).
- As of February 25, 2005, Westlaw KeyCite generated a list of 189 cases citing to *Georgia-Pacific*.
- From this initial list of 189 cases, the following types of cases were eliminated:
  - cases pertaining to litigation over discovery, including motions to compel, motions in limine, etc.;
  - cases that found no infringement;
  - nonpatent cases, such as bankruptcy, tax, and trademark cases;
  - cases without a final history, for example, cases that were remanded;
  - cases in which liability was found, but damages had not yet been determined;
  - cases that awarded lost profits rather than a reasonable royalty; and
  - cases that were decided in 1983 or prior to 1983.
- Thus, the remaining cases that were *not* eliminated were patent cases in which:
  - infringement was found;
  - a reasonable royalty was awarded;
  - the judgment was affirmed or otherwise not appealed; and
  - the case was decided after 1983.
- The final data set consists of fifty-eight cases.
- Of those fifty-eight cases, eleven of them award a reasonable royalty, but do not express the royalty as a percentage of the purchase price.
- Thus, the "working" data set consists of forty-seven cases from which summary statistics have been calculated.